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HIGH SCHOOL APPRENTICESHIP PROGRAM

1989

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VOLUME III OF III

UNIVERSAL ENERGY SYSTEMS, INC.

Program Director, UES
Rodney C. Darrah

Program Administrator, UES
Susan K. Espy

Program Manager, AFOSR
Lt. Col. Claude Cavender

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INTRODUCTION

In the near future the United States may face shortages of scientists and engineers in fields such as physics, electronic engineering, computer science and aeronautical engineering. High School students are currently not selecting to prepare for careers in these areas in numbers large enough to match the projected needs in the United States.

The Air Force faces "a formidable challenge - the acquisition and retention of the technological competence needed to ensure a strong national security, both in-house and in the industrial and academic base which supports defense preparedness." The Director of the Office and Science of Technology Policy in the Executive Office of the President in 1979 responded to this need by requesting the federal agencies to incorporate in their contract research programs the mechanisms to stimulate career interests in science and technology in high school students showing promise in these areas. The Air Force High School Apprenticeship Program is an example of the response to this.

Under the Special Studies section of the Summer Faculty Research Program an Air Force High School Apprenticeship was initiated. This program's purpose is to place outstanding high school students whose interests are in the areas of engineering and science to work in a laboratory environment. The students who were selected to participate worked in one of the Air Force Laboratories for a duration of 8 weeks during their summer vacation.

The Air Force High School Apprenticeship Program was modeled after the Army's High School Program, which is very successful.

The following time schedule was used in order to accomplish this effort.

GEOPHYSICS LABORATORY

Determining Typhoon Wind Intensity Using SSM/I Brightness Temperature Data

Stephen C. Britten

8/25/89

Department Of The Air Force
High School Apprenticeship Program
Geophysics Laboratory (AFSC)
Atmospheric Sciences Division
Hanscom Air Force Base, MA 01731-5000

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1.0 BACKGROUND AND INTRODUCTION

On June 19, 1987 the Air Force successfully launced a DMSP (Defense Meteorological Satellite Program) polar orbiting environmental satellite from Vandenberg AFB, California. The mission of DMSP is to provide global visible and infrared cloud data as well as specialized data for meteorological, oceanographic, and solar-geophysical fields, all of which are required in order to support DOD (Department of Defense) operations. These data are acquired, real-time, through a total satellite system consisting of spacecraft with sensors at 450 nmi sun-synchronous polar orbits, an earth-based command and control network, user stations, launch vehicle and support, and a communication network linking the various segments together. Stored data are transmitted to the AFGWC (Air Force Global Weather Central) at Offutt AFB, Nebraska, for processing and distribution.

There are 5 major sensors aboard the DMSP satellite. The OLS (Operational Linescan System) is the primary sensor providing visible and infrared imagery. The SSM/T, a passive microwave temperature sounder, provides data for profiling atmospheric temperatures up to a height of 30km. The SSJ/4, a precipitating electron spectrometer, determines the location of the auroral boundary, aiding communications. The SSB, a gamma/x-ray detector, provides electron and x-ray density profiles for specialized Air Force programs. Finally, the Special Sensor Microwave/Imager (SSM/I), the sensor with which this report is concerned, measures the dual-polarized microwave radiation from the atmosphere and surface at 4 different frequencies, 19.35, 37, 85.5, and 22.3 GHz. The first three have both horizontal and vertical polarization possibilities while the fourth measures only vertically polarized radiation in a water vapor absorption band. The specialty of this instrument lies in the fact that the microwave measurements of the surface are relatively insensitive to cloud cover and thus can be made under nearly all weather conditions. The SSM/I sensor has parameter performance requirements formulated for thirteen parameters, ocean surface wind speed, ice age, ice coverage, ice edge location, soil moisture, cloud water, liquid water, precipitation rate over land, precipitation rate over water, snow water content, land surface temperature, integrated water vapor over ocean, and cloud amount over land. Due to its relatively small swath width of 1,394 km, daily coverage has gaps below the 65 degree latitude mark. Despite the gaps, the SSM/I is of great use to the Air Force because it is a good source of data for tropical cyclones. In particular SSM/I data are very helpful to the Joint Typhoon Warning Center (JTWC) because weather planes are no longer being regularly flown into typhoons in the North Pacific Ocean. The DMSP satellite that was launched on June 19, 1987 was the first weather satellite to carry this microwave sensor.

JTWC is a weather facility located on Guam in the West Pacific and manned by both Navy and Air Force personnel. While the Navy works on the prediction aspect of the typhoons the Air Force is responsible for furnishing the real time data. The JTWC was set up in 1959 to monitor and issue warnings on tropical cyclones in the North Pacific region but has since expanded its monitoring area to both the northern and southern hemispheres from the international dateline westward to the east coast of Africa. It's mission, using data gained from the DMSP, weather buoys, surface ships, aircraft reconnaissance, and radar reconnaissance, is to monitor, issue alerts and warnings on, and find new methods to predict tropical cyclones in the areas stated above.

This report will deal mainly with SSM/I data at 85 GHz vertical and horizontal polarization, and 37 GHz horizontal polarization as it relates to the storm intensities of tropical cyclones during 1987 in the North Western Pacific Ocean.

2.0 SSM/I DATA PROCESSING

Most of the SSM/I data is not useful for studying tropical storms in the Pacific because the DMSP satellite is a polar orbiter and thus gathers data from around the globe. Therefore the first task is to locate the latitude and longitude of the tropical storm at a given time and compare it with the position of the satellite. When the desired data is determined it is extracted from the magnetic computer tapes and used to generate images on an RGB monitor. To drive the guns of the RGB monitor the brightness temperature data, ranging from 120K to 295K, must be converted into integers between 0 and 255. A brightness temperature of 120K is represented by a greyshade of 255 while a brightness temperature of 295K is represented by a greyshade of 0. Assigning the 85 GHz vertically polarized data to the red gun (channel 0), the 85 GHz horizontally polarized data to the green gun (channel 1), and the 37 GHz horizontally polarized data to the blue gun (channel 2) and then overlaying the three on the RGB screen presents an image that, when analyzed with similar images from other storms, becomes the foundation upon which the actual research is conducted upon. In order to have a reference point on the generated image that corresponded to the tropical disturbance, a point that most resemble . an eye was located, using a computer program named Toggle, and its screen coordinates recorded.

3.0 INTERPRETATION OF SSM/I COLOR IMAGES

Brightness temperatures measured at microwave frequencies are largely dependent upon the emissivity of the given feature. The ocean which has a low emissivity appears blue while land with a high emissivity appears dark. Atmospheric constituents such as water clouds, light precipitation, and water vapor radiate more than the surrounding clear atmosphere ocean regions and thus appear a darker blue to grey-black. These atmospheric features are hard to "see" over land due to the large amount of background radiation. Large raindrops and ice particles located in upper reaches of tall clouds tend to scatter the microwave radiation away from the satellite extensively lowering the brightness temperatures, especially at the higher frequencies such as 85 GHz thus producing a bright yellow color (see figure 1). Hypothesizing that the brightest areas represent those areas of greatest convection, I conducted a series of experiments to determine if there is a direct link between the distribution of brightness temperatures and the storm wind intensity.

4.0 RESEARCH ANAYSIS AND RESULTS

4.1 RESEARCH1: BLIND AVERAGING IN BOXES

The average brightness temperature was determined, for each channel separately, in different size "boxes", varying from 5 pixels in radius to 70 pixels in radius, centered about the prerecorded eye. After repeating this averaging process for all 17 cases, the acquired average brightness temperature data and storm wind intensity data from JTWC were put into a linear regression analysis using LOTUS 123. (NOTE: all experiments discussed later will use this same box averaging technique followed by the generation of a regression). This regression furnished a number, R-squared, which, when multiplied by 100, gives the percentage of the variation of one term which can be attributed to the other. The results of this experiment, while nowhere close to being perfectly aligned with the hypothesis (R-squared values only slightly higher than .2, an R-squared greater than .5 being acceptable), did correspond with the belief that there is some sort of link between brightness temperature and storm wind intensity. For all box radii of the two 85 GHz channels the slope of the regression line was negative while for all box radii of the 37 GHz channel the slope of the regression line was positive (see figures 2,3)

4.11 PROBLEMS WITH RESEARCH1

The technique used in research1 did not account for pixels in the "box" that were not part of the actual typhoon cloud and rain bands, blindly averaging in areas of slight cloud cover, open ocean, and in some cases even warm land. This resulted in a "bias" that gave colder averages to some storms, those which were larger in size, had tighter cloud bands, or contained more centrally placed eyes, simply because they happen to cover more of "the box" (see figures 4,5). Since size and symmetry have little bearing on the strength of a typhoon, this technique can certainly be improved.

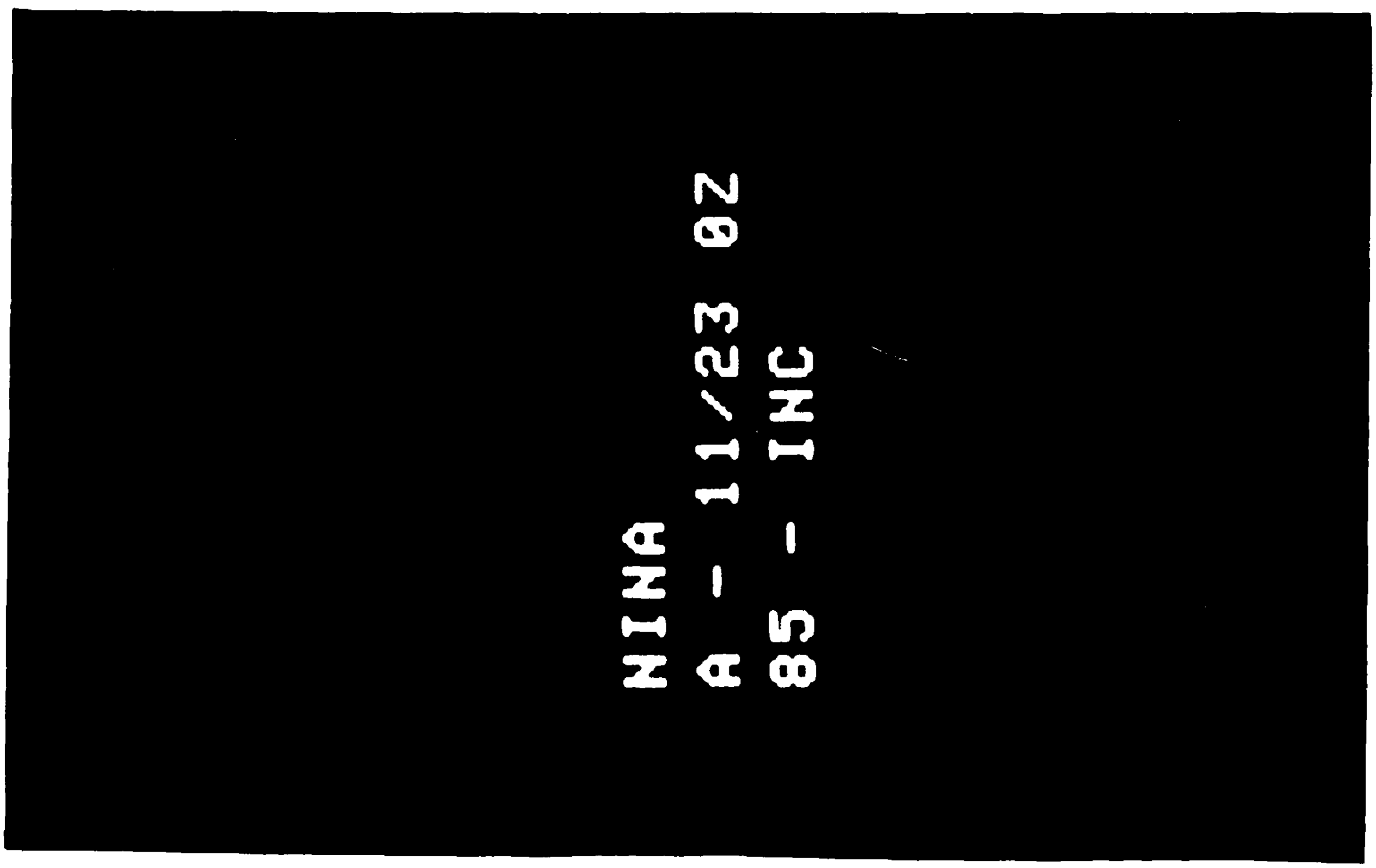
After research1 in order to be able to study many different techniques, I decided to study only one channel, the 85 GHz vertical, chosen because the 85 GHz horizontal is no longer operational and because it showed more promising R-squared values than the 37 GHz horizontal.

4.2 RESEARCH2: A STUDY OF THE EXTREME

To avoid the suspect problems with research1, the next test was designed to analyze only the lowest brightness temperature in a given box, the lowest 21 brightness temperatures averaged in a given box, and the lowest 100 brightness temperatures averaged in a given box (box sizes again ranged from 5 to 70 pixels). This method would therefore eliminate all of the warm ocean and land points and strictly look at the coldest points of each storm, believed to be the areas in which the maximum convection was occurring. Surprisingly there seemed to be only a weak link at best between the coldest brightness temperatures and the intensity of a storm as the R-squared values remained below 1/10 (see figure 6). This gives the impression that storm intensity is not determined by the effects of one, two, twenty, or one hundred individual areas but rather by the cumulitive effect of the entire "storm" as a whole.

4.3 RESEARCH3: ELIMINATING THE UNWANTED PIXELS

Feeling that the disappointing results obtained from research2 were due mainly to its specificity, I decided to use a very similar technique to the one employed on research1 but instead of focusing soley on the extremes as in research2 I attempted to eliminate only the ocean/land background and some lower clouds. I tried three sub-experiments, one averaging all brightness temperatures less than 247K in the given box, one averaging all brightness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figures 2,3

The upper graph contains information obtained by averaging brightness temperatures from channel 1 (85 GHz vertical) in a box radius of ten pixels centered about the eye. The squares represent the average brightness temperature for a given case while the line is the regression between the brightness temperatures and the intensities. The lower graph is the same as the upper graph except the temperatures are from channel 2 (37 GHz horrizontal) and the "pixel radius" is five.

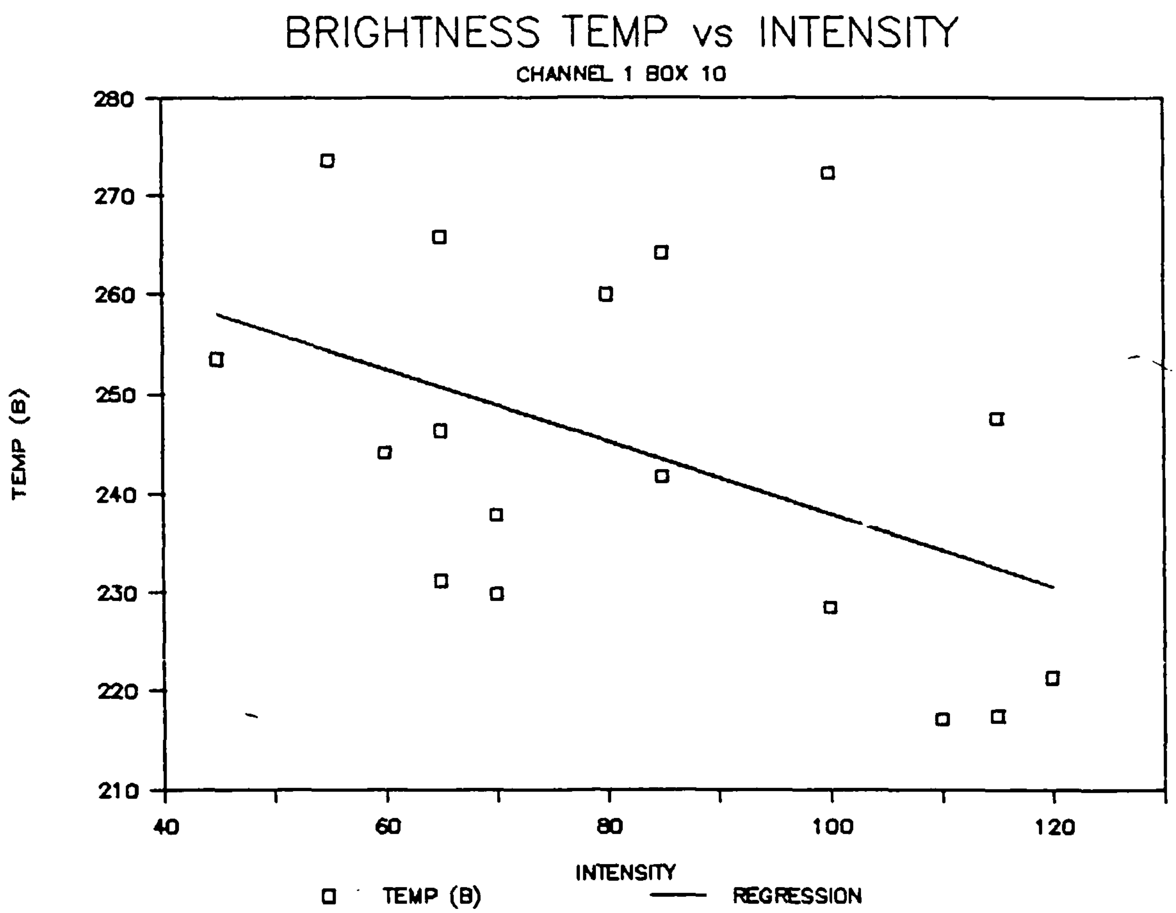
temperatures less than 260.7K in the given box, and one averaging all brightness temperatures less than 267.5K in the given box. The results from research3 were much improved, with the R-squared in the <267.5K box almost reaching 3/10 (see figure 7).

5.0 CONCLUSION: ONLY A TEMPORARY DISAPPOINTMENT ???

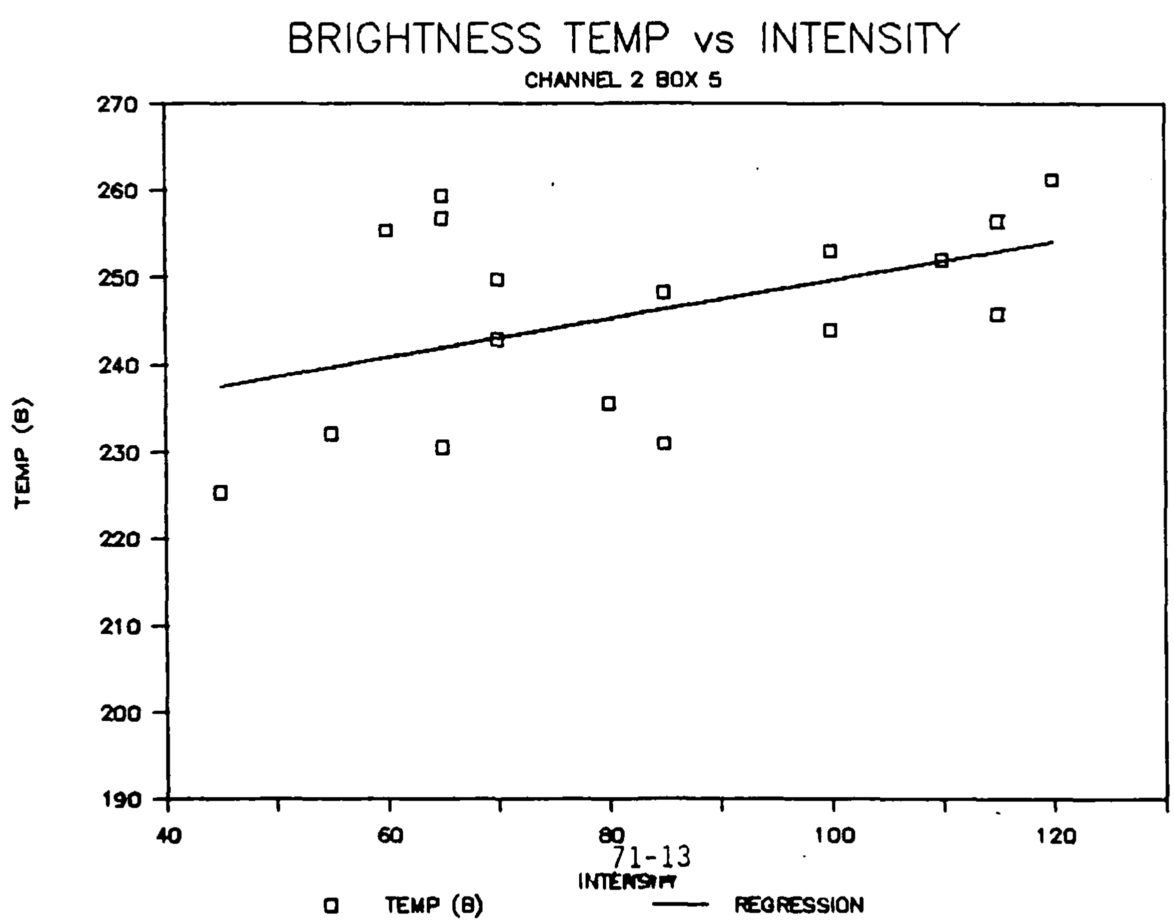
Although the R-squared value never went above .3 in any of my experiments, which indicates that these methods could not possibly be expected to determine the intensity of the storm with any claimed accuracy using brightness temperature data alone, the results seem to indicate that there is at least some kind of link between storm wind intensity and some sort of average SSM/I brightness temperature. However, I believe that in order to produce an accurate model for determining storm intensity it will be neccessary to take other factors into account before applying the brightness temperature data. Factors, such as the latitude of the tropical storm, the season in which it occurs, the temperature of the underlying water, and the shape of the storm, will be needed to regulate what the brightness temperature data actually represents for a given typhoon. Once relationships are discovered, between factors such as these, brightness temperatures, and intensities of typhoons, accurate models will be soon to follow.

figure 1

Notice the bright yellow color, signifying ice particles in the upper areas of tall clouds, of typhoon Nina. The dark blue-black regions south-east of the "eye" are probably low clouds. The black area in the south-west corner is land.



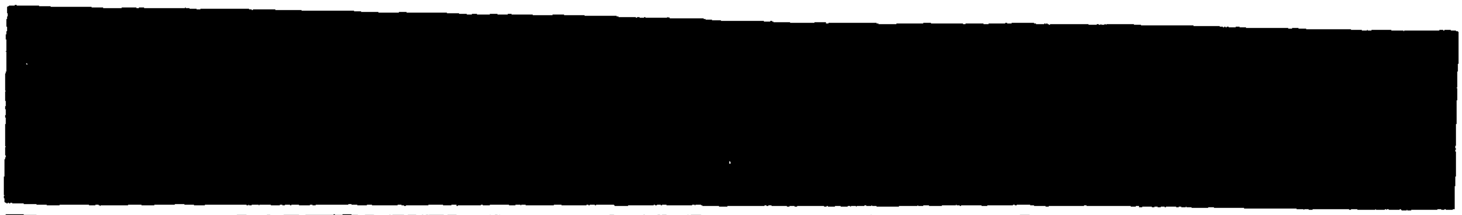
BRIGHTNESS TEMP vs INTENSITY
CHANNEL 1 BOX 10
280
270
260
250
240
230
220
210
TEMP (B)
40
60
80
100
120
INTENSITY
TEMP (B)
REGRESSION



BRIGHTNESS TEMP vs INTENSITY
CHANNEL 2 BOX 5
270
260
250
240
230
220
210
200
190
TEMP (B)
40
60
80
100
120
INTENSITY
TEMP (B)
REGRESSION

figures 4-5

Note the extreme difference in size, band density, centrality of eye, and general shape of these two typhoons. Yet, despite their differences, they have the same intensity.



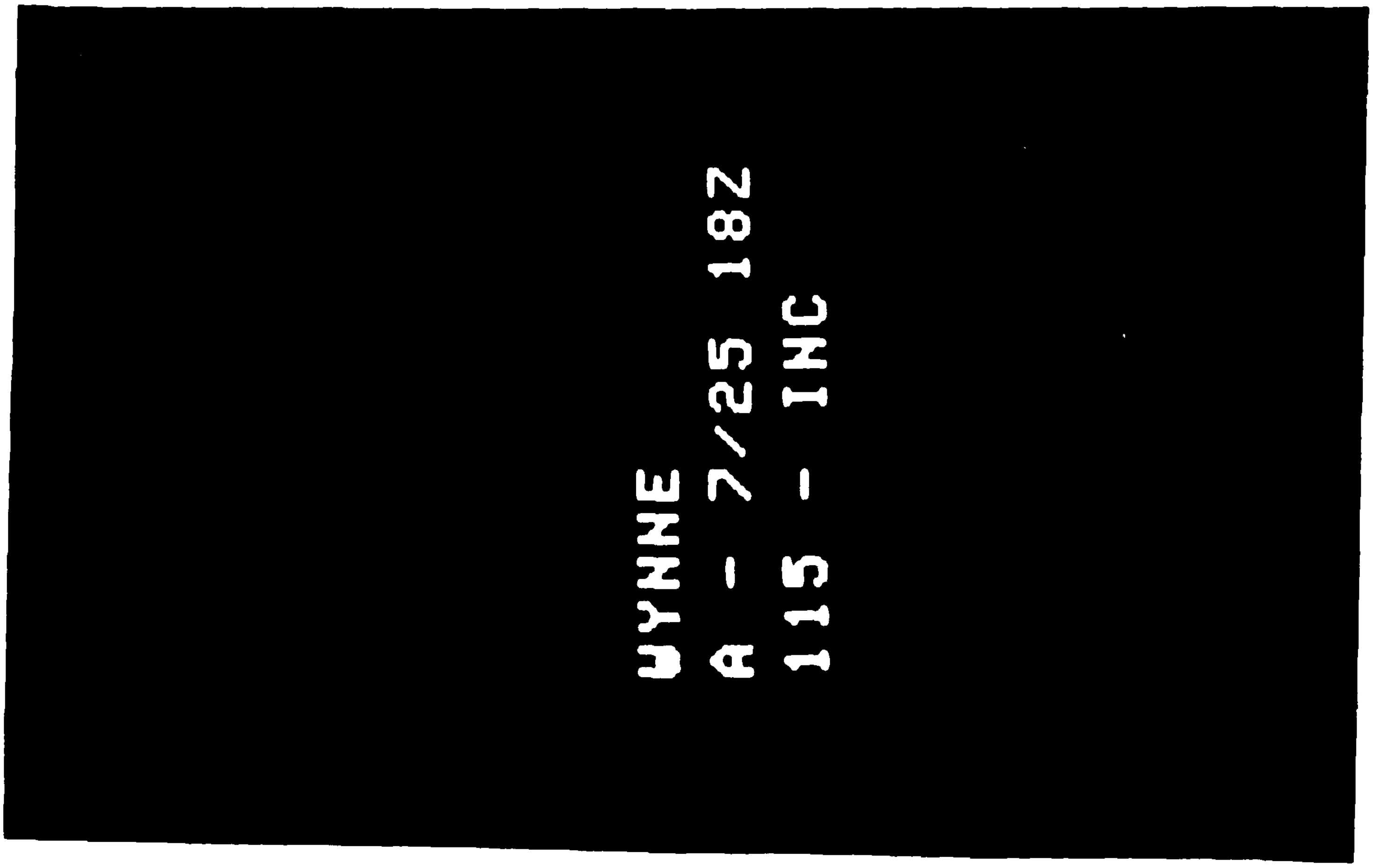

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figure 6

This graph demonstrates that there is almost no relationship between the top 100 brightness temperatures in a box radius of 25 pixels on channel 1. Similar results were obtained for the other box sizes.

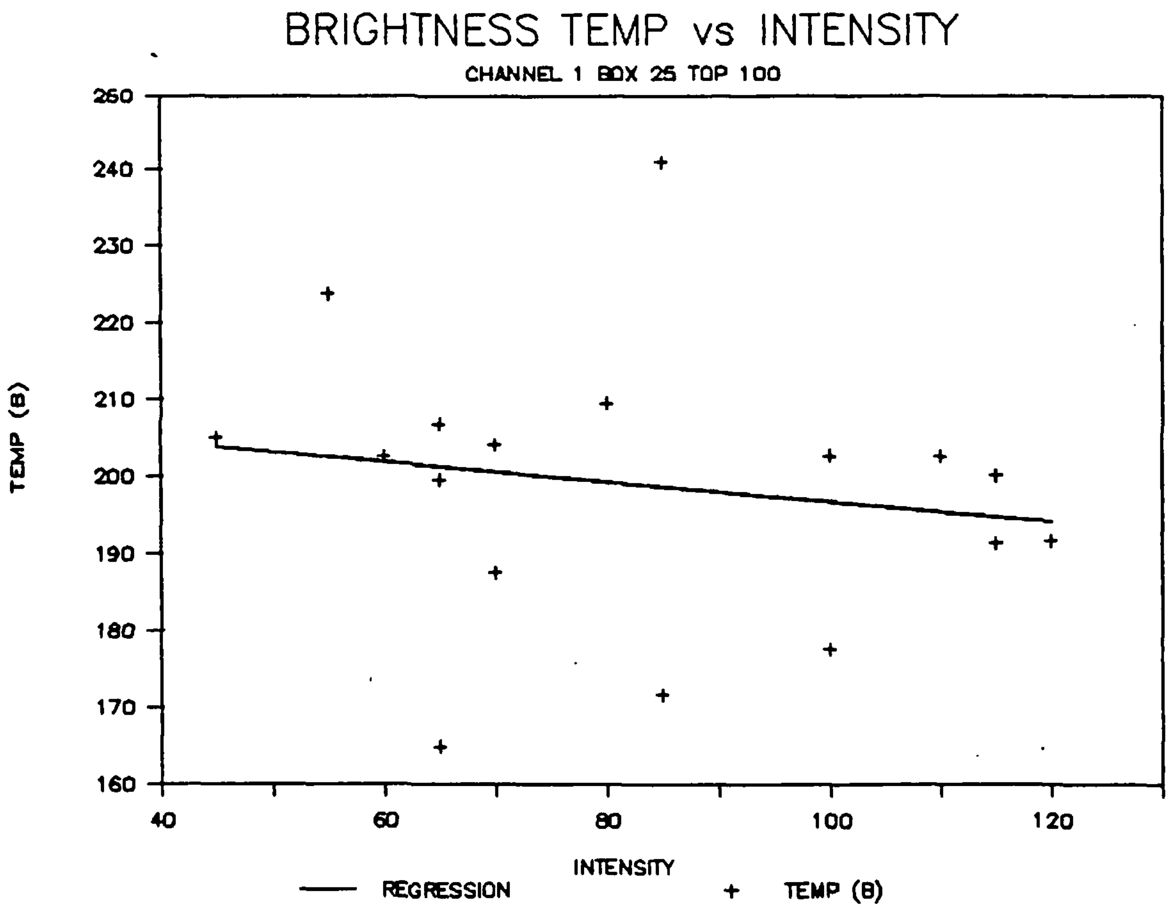
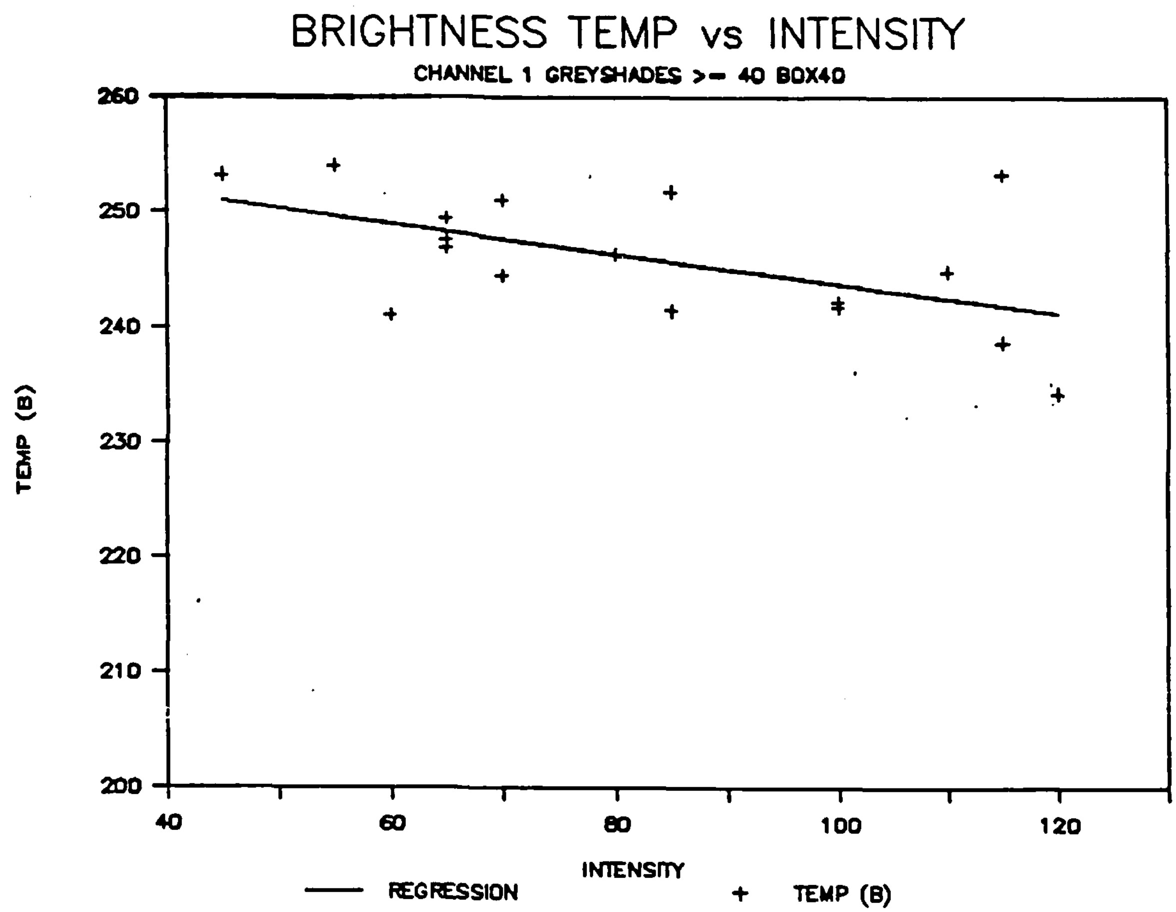

BRIGHTNESS TEMP vs INTENSITY
CHANNEL 1 BOX 25 TOP 100
260
240
230
220
210
200
190
180
170
160
TEMP (B)
40
60
80
100
120
INTENSITY
REGRESSION
TEMP (B)

figure 7

Averaging all the greyshades greater than 40 (all the brightness temperatures less than 267.5K) gave the "best" results. At a box radius of 40 pixels on channel 1 it had an R-squared value of .237.



BRIGHTNESS TEMP vs INTENSITY
CHANNEL 1 GREYSHADES >= 40 BOX40
260
250
240
230
220
210
200
TEMP (B)
40
60
80
100
120
INTENSITY
REGRESSION
TEMP (B)

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Artificial Intelligence and Lightning Prediction

by Brian Burke
September 1, 1989

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Thank you.

Introduction to Artificial Intelligence and Neural Networks

Artificial intelligence is a discipline of Computer Science in which researchers and computer programmers attempt to make computers mimic the learning and decision abilities of humans. The initial interest in artificial intelligence was sparked by a summer conference at Dartmouth College in 1956. One of the prominent researchers who attended was Marvin Minsky from the Massachusetts Institute of Technology. He had done work with an artificial intelligence system called a neural network. In 1959 he published a book on the perceptron network (invented by Frank Rosenblatt from Cornell) which disproved the theory of neural networks. This book stopped all but a few researchers from exploring neural networks for two decades. Researchers have recently restarted the study of neural networks however, and have made great advances and, to some extent, proved Minsky wrong.

The Human Nervous System

A neural network is a system based on the theory that computers will best be able to make decisions if they can learn like humans. Research has shown that the human thought process is part of the nervous system. The brain is made up of many units called neurons. Each neuron consists of many dendrites (input paths), synapses (connection strengths), and an axon (output path). The "inputs" come through the dendrites to the synapses. The synapses then transfer a fraction of the signal onto the central cell of the neuron. If there is a large enough signal coming into the neuron from all of the dendrites and synapses, then the neuron will "fire" a positive charge through the axon and on to other neurons. As can be inferred from this description, the synapses control the process because the strength that they possess is making the decision in the system. The human brain is made up of tens of billions of neurons.

Neural Network Architecture

The idea of a computer neural network is to replicate the human reasoning system. The computer neural network consists of several parts (see figure 1). First, there is the input layer. This is a layer of processing elements. A processing element is the equivalent to a neuron. Between the input and output layer is usually at least one "hidden" layer. This layer is present for the internal processing the system is expected to do. Finally there is the output layer, where the processed data is represented. There is also a "bias" processing element which always sends out a value of one. This is used to provide mathematical consistency. Each processing element from each layer is connected to all of the processing elements in the layer immediately above it with the exception of the bias which is connected to the hidden layer and the output layer. Beyond this basic architecture, there are many different types of networks. These networks are different in the way they are connected and how they adapt to learn the given information.

Back Propagation

The network studied in this project was the back-propagation network. David Rumelhart is credited with the invention of the back-propagation network. The theory behind back-propagation is that, if there is an error in the system, then all of the inputs are partially to blame for the error and, therefore, all of the connection weights should be changed. This was a way of solving the problem of credit assignment as posed by Minsky and Papert in their book <u>Perceptrons</u>. The network works in the following way: One set of inputs is taken from the data file. Each element in the hidden layer computes an "internal" value by multiplying the connection weights by the values of the processing elements. The "internal" sum is then processed using the sigmoid function:

$$f(x)=\frac{1.0}{1.0+e^{-x}} \quad (1)$$

This new value is then transferred to all of the elements in the output layer which goes through the same process. If the network is in a learning phase, it computes the global error and transmits this value back through the connections. The network then alters its weights to try to account for the error.

Lightning Background

The field mills at Kennedy Space Center measure the vertical electronic field in volts per meter. There are thirty one such mills in their network of instruments. When lightning occurs, there is a drop shown in the values of most of the mills. In order for the computer to be able to predict lightning, it will have to recognize a pattern that generally precedes this behavior.

Goals of Research

The overall goal of this Geophysics Laboratory research project is to design and train an artificial intelligence network to predict lightning. At this time, however, there is insufficient data to complete this task. The data of lightning occurrences is not yet available. The interim goal of this research is to determine how many degrees of freedom are required for the final product. The number of degrees of freedom is indicative of the extent to which the data can be compressed without loss of accuracy. Beyond the degrees of freedom that are required, research was also done to determine if a number of "important" mills can be used instead of compressing the data. If this is possible, it would allow the task to be carried out at a much greater speed.

Apparatus

To conduct these experiments, a Heath/Zenith Z-248 personal computer was used. This computer is equipped with an Enhanced Graphics card to display the data. The software used was NeuralWorks II Professional which is published by NeuralWare Inc.

The Data

The data that were used for this project were electronic field mill data that were recorded on July 18, 1988 at Kennedy Space Center. On the tape it has integer values that range between -750 and 600 (for the part of data that was used). Four records of data per second provides approximately 350,000 records per day . This is far too much data to work with for simple experiments. (It would take over four days to process it all once with the Z-248 computer system that was used.) A small section of data were elected to work with for this reason. After examining various sections of the data it appeared that the most thunderstorm activity was occurring at about 1200Z hours. In order to properly verify results, sets of data that showed little activity were also chosen and used. One was taken at 0411Z and the other at 2036Z. A total of 12,000 records were used for these experiments.

There appeared to be two mills that were malfunctioning. Mill #11 was reporting 1500 until the 2036Z data, and Mill #30 was recording varied data. Therefore, these two mills were set to integer 0.

Initial Processing of the Data

When data were first put in, it was not altered in any way, but was just input as integers. This produced very unacceptable responses from the neural network. The network accepted the large input values, but the output layer always had each element set to 1. It was obvious that the data had to be in a certain range. At this point it was learned that the data should be normalized to values of between one and negative one. This was accomplished by having the data processed (normalized) by dividing by 400. This produced values that were for the most part within the given range. There still seemed to be a problem. It was discovered that the back-propagation network cannot adapt very well to negative values. A value of 0.5 was then added to the results of the original value divided by 1500 (to allow for a greater range). The following formula was the result:

$$f(x)=\frac{x}{1500}+0.5 \qquad (2)$$

This function gives values that are mostly between 0.0 and 0.7. These were the values that were given to the neural network for the experiments. Experiments also showed that the best way to make the network disregard mills #11 and #30 was to set them to a value of 0.0 after this processing, it was equal to -750 which was not the case for these two mills, but it was observed that by doing this, the network always set little priority on these mills.

Network Setup

A back-propagation network was the type chosen for this task. This was chosen because the output degrades gracefully as the input data degrades. The network was designated as an auto-associative network which means that the outputs should equal the inputs. The network used consisted of a bias, an input layer of 31 processing elements, a hidden layer of 15 elements (originally), and an output layer of 31 elements. This network contains 976 interconnects (see Figure 2).

The weights were set to random values between -0.10 and 0.10. The data had a range of .15 to .7. The procedure was to setup the network to learn several thousand records of data. After the learning cycle, the connection weights between the input layer and the hidden layer would be examined to determine which elements from the input layer had the largest overall weight associated with it. After running several trials some interesting behavior was exhibited by the network.

Number of Needed Processing Elements

The hidden layer originally had fifteen processing elements. After the network had been trained with 2000 records, it was observed that only eight of the elements in the hidden layer were "firing" values greater than 0.5. The other seven elements were all transferring values around 0.0. This indicates that there were only eight degrees of freedom which indicates that the majority of the information might be contained in just eight of the 31 mills.

At this point, in order to help validate this assertion, a network was set up with a bias, 31 inputs, a ten element hidden layer, and thirty one outputs with the outputs being the same as the inputs. Once again it appeared that only eight of the elements from the hidden layer were showing a substantial value. Based on these observations, it was concluded that the information contained in all 31 inputs can be compressed to eight inputs without a major loss of accuracy.

What This Means

There are two possible implications of this fact. First, it could m,>>> that the data can be compressed into eight processing elements. This would mean that, with the data from these eight elements, and the connection weights to the output layer from the hidden layer and the bias, then we would be able to expand these eight items to get the 31 pieces of data.

The other possible result is that all of the data that is held in the thirty one mills is really only held in eight mills. In other words, we should be able to pick out a certain eight mills and be able to use just these data instead of the whole set. This would be an ideal situation because at this time, the computer cannot handle that much data in a reasonable amount of time. (The technology to do this does exist, but not with the setup used for this project.) In order to determine which of these two situations is correct, we will attempt to prove that the latter is correct. If not, then it can assumed that the former is correct.

Is the major part of the information available in just 8 mills?

In order to fully determine if all of the information that we want is contained in eight mills, the final network to predict lightning would have to be completed. Then the full set of thirty one mills would have to be tested against the set of eight chosen mills. At this time, the data of lightning occurrences is not yet available, therefore, it is not possible to complete the task in this manner.

Observations which will now be discussed make some of this testing possible.

Observations

When data were fed into a network with eight elements in the hidden layer, and thirty one elements for input and output, it seemed that the computer was able to determine when lightning occurred on its own. (It was not able to predict it though.) An "instrument" was installed in the network to display the progress of the networks learning. This instrument was set up to measure the total error of the network. It had a scale of 0.0 to 0.01 (see figure 3). As a data set was fed to the network, one could observe the error start off on the graph at the top of the screen, and then drop into a range that was very close to 0.0 (0.002 was the average). At certain points however, a large increase in the error was evident. This increase could be attributed to the fact that there was an anomaly such as a lightning event or calibration of one of the mills.

When lightning occurs, there is a change in the values of most of the mills. If the network was trained to reproduce the values of the mills, it would get into a pattern. It is in effect, only recognizing a pattern. The prevailing pattern in the field mili data shows little change in the values of the mills. When there is a change, the mill does not expect it and therefore the network is slightly wrong in the numbers it reproduces. A larger than normal error is thus displayed on the graph. A simple illustration of this phenomenon is as follows. In a network a certain element is always transferring a value of 0.75. The network gives this mill larger connection wights than usual because it can always count on a value of 0.75. If that value changes to 1.0, then the network will reproduce values greater than the inputs which is in error. This is what the network was doing.

The point from this is thus, by examining the error exhibited by the network, it should be possible to tell when lightning occurred.

What Mills are Important?

The final question is if there are eight degrees of freedom and they correspond to just eight mills, which ones are they? As discussed earlier, the best way to do this would be to test the eight selected with the final network. Based on being able to determine when lightning occurred as previously discussed, it should be possible to get similar results. If a network is set up with eight hidden elements, and thirty one inputs and outputs, examining the weights between the input and hidden layer should give the required results.

What Makes Weights More Important than Others?

For this experiment, a simple function has been set up to determine which elements have the greatest weights. Five colors have been assigned to weights as follows:

.050	<	Blue		
.000	<	Red	<	.050
-.025	<	Purple	<	.000
-.050	<	Yellow	<	-.025
		Black	<	-.050

Since the processing elements from the input layer are trying to be encoded into the processing elements in the hidden layer, the elements that have the most positive weights are winning the battle. There are several ways to compute the overall value for the weights from each element in the hidden layer. First is to get the actual value of each connection from the Neural Net program and total them up. After that, you would simply take the totals of each element and pick the top eight. Although this seems like a good way to do it, it is impractical for doing many trials because there would be over 150 calculations per trial. A simpler algorithm was chosen. A display was chosen that presents the colors of each connection. A data table was set up to record the number of each color of connection for each element. Therefore, there were five values per input element. The function to compute their worth is as follows:

Blue*3 + # Red*2 + # Purple - # Black (3)

This is an arbitrarily chosen weighted average for the values. A column was then set up that contained the "computed value" for each mill. The computed values were then ranked in order from largest to smallest. (See data table 1 attached) It was determined that the elements with the largest computed values are the most important to the system. After several trials using different sets of data and different numbers of records, there appeared to be a convergence on a few mills that were important. These mills have the following numbers: 6, 8, 9, 10, 14, 20, 26, 33. (See data table 2 attached) As you can notice, there are eight mills listed. This seemed appropriate based on the data.

At this point it should be said that there are critics who believe that it is possible to determine how many mills are important, but that determining which mills they are is not possible. The data used for this report indicates that the above eight mills are correct. In making the final network setup, it would be prudent to use ten mills to allow for the possible failure of one or two mills.

Testing these eight mills

In order to further prove that these eight mills are sufficient for the purpose, a network similar to the original network was set up. In this network, however, there were only wight inputs and outputs, and three elements in the hidden layer. The same instrument was installed to measure the error. The procedure used to determine if these mills were sufficient was to attempt to achieve a similarly low level of overall error, but still be able to see the peaks that seemed to indicate lightning. The graph of error seemed to be very similar to the graph displayed when thirty one mills were used. The only difference was that the graph of eight mills was not as smooth as the graph of all thirty one mills. (See figures 4 and 5)

Recommendations for further research

At the writing of this report, the data of lightning occurrences was not yet available. Several options are available for what to do once these data are available. It would be best if a network was created with all thirty one mills in the input and the appropriate three elements in the output layer (predicting lightning within three time intervals). It will not be easy to get the network to be able to predict lightning immediately. Many modifications will probably have to be made to the back-propagation algorithm in order to achieve this goal. Once a reasonably reliable network has been trained, a new network should be formed using the appropriately determined algorithm. This new network should have only eight to ten mills to represent the above chosen mills. The error produced by this network should then be compared to the error displayed by the larger network and a decision made.

Errors

It is difficult to identify any errors in the work that has been done. In order for this to be possible, more data is needed to test the work done to date.

Conclusion

In conclusion, it is apparent that predicting lightning is a very difficult task. Preliminary results indicate that the network was able to tell when lightning occurred after the fact. Three discoveries were made. First, the artificial intelligence network that was used was able to indicate when lightning was occurring after it had happened. Second point is that the set of 31 mills that were used can be mirrored to only eight mills. Finally, the eight important mills are numbered: 6, 8, 9, 10, 14, 20, 26, 33.

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Final Report

The Aurora: a comparative study of the correlation between Kp and Bz values and oval diameter

Prepared by: Eric E. Eisenberg

Research Location: Hanscom Air Force Base
Bedford, Ma

USAF Mentor: Dr. Richard Eastes

Date: August 11, 1989

II. Acknowledgements

My eight weeks at the Geophysics Lab at Hanscom Air Force Base were made enjoyable and meaningful because of the many people who helped me. I would like to extend my biggest thanks to Dr. Eastes for providing me with this opportunity to explore a scientific field. I must thank him for his guidance and patience throughout the entire project. Thank you Frank Delgreco for your computer expertise and always knowing what I did wrong and how to fix it. Thanks to Frank Leblanc for his sailing knowledge and his help with extracting data from long forgotten but not lost tapes. I cannot forget to thank Joe Thomas and Tony Dentamaro for their incessant bad jokes and their coincidental timing of appearing whenever I was about to put my head on my desk. Thanks guys. June McNamara deserves a big thank you because she would always be kind enough to assist me in the little things I needed help with. I also have to thank Maki, Susan, and Kathy for putting up with my complaining, groaning, and making lunch the highlight of the day. Thanks to Ann Lambert and her staff for arranging and organizing this opportunity for me. Thanks to Jim Whalen for his zoom transfer scope and the time he made available to me to discuss the aurora. And finally last but not least, I thank all those in the Ultraviolet Surveillance branch, Dr. Huffman, Vic Baisley, Chris Stergis, Judy Welsh, Charles Forsberg, Dan Katayama, and Joe Larrabee for making me feel welcome.

III. General Description of Research

My first few days at the Geophysical Research lab were very intimidating and at times I thought I would be in over my head all summer. All I could think about was how frustrating this would be. I was given dozens of articles and books to glance over. To my good fortune, things were not really over my head. In fact I became very comfortable after the first week of the program. It was then that I began to understand just what an aurora was and why the government had an expressed interest in this naturally occurring phenomenon. An aurora can usually only be seen near the north and south geomagnetic poles. Here is one explanation I read by Robert H. Eather in his book Majestic Lights [1980] which seems to fully describe the aurora. "The sun is a very hot gaseous body, so hot that it continually 'boils off' atomic particles- protons and electrons. These particles stream out from the sun in all directions into interplanetary space and constitute the so-called 'solar wind.' After a couple of days a small fraction of these particles reaches the vicinity of earth. Their first indication that anything unusual is in the offing is when they encounter the earth's magnetic field, which stretches tens of thousands of miles out into space. Magnetic fields affect the trajectories of electrically charged particles, and in this case, the shape of the earth's magnetic field acts to guide some of these solar wind particles to two oval-shaped regions around the north and south poles. These ovals are located some 23 degrees latitude from the poles, and this is the region where auroras occur every night of the year. As these solar wind protons and electrons are being guided down to lower altitudes of the earth's atmosphere, they are also accelerated to higher velocities. The fast particles then collide with the earth's upper atmosphere- the oxygen and nitrogen. A process then occurs which is analogous to the operation of a neon light tube: in the light tube, fast electrons collide with neon gas and give some of their energy to the gas, which is then radiated in the form of light. The same thing happens in the earth's atmosphere (at a height of about 60 miles), except here it is the oxygen and nitrogen that emit light. This is the light of the aurora, and its color depends on the height. The faster the precipitating particles, the deeper they penetrate into the atmosphere. But the composition of the atmosphere- the relative amounts of oxygen and nitrogen atoms and molecules- varies with height, and each gas gives out its own particular color when bombarded by these fast particles. Consequently, certain colors originate preferentially from certain heights in the sky, and the range in velocity of the incoming particles results in the wonderful variety of color of the aurora."

There is a basic classification system for the general shape of the aurora. Although I did not research the aurora from ground observations and this classification is not pertinent to my research, this will give you an idea of the diverse variety of auroras in the sky. Again, the book Majestic Lights [1980] gives an excellent description. "Five forms are defined as fundamental in the identification and reporting of auroras: arcs, which appear as simple slightly curving arcs of light with smooth lower borders; bands, which have continuous but irregular lower borders characterized by kinks or folds; patches, which are isolated small regions of luminosity, often resembling patches of cloud; veil, which describes an extensive, uniform luminosity which covers a large fraction of the sky; and rays, which are shafts of luminosity inclined to the vertical (in the direction of the earth's magnetic field)."

The data which I analyzed came from the AIRS instrument which is on the Polar BEAR satellite (see figure 1). The AIRS instrument has four different instruments which are sometimes referred to as detectors. AIRS, which stands for Auroral/Ionospheric Remote Sensor, obtains daylight and nighttime ultraviolet images of the aurora around the north pole. I used information entirely from detector two which is a spectrometer. The spectrometer acts as a filter. This enables scientists to use data obtained from this detector to produce an image of the aurora.

The Air Force is interested in the aurora because radar systems are disturbed when in contact with an aurora or other intense ultraviolet activity. The charged particles colliding in the earth's atmosphere make it very hard if not impossible for the Air Force to track anything during periods of intense auroral activity. When activity on the sun increases, so does the amount of charged particles emitted from it. This means the radar interference is worse. In fact, any instrument which uses some kind of radio signal, is apt to be affected. (Yes, even automatic garage door openers.) The atmosphere becomes ionized and this causes radio waves and radar waves to be deflected resulting in a radio "black out." Fortunately, this behavior usually occurs in the north pole region. The aurora is rarely seen in New England (see figure 1a).

IV. Detailed Description of Project

My project focused on examining the auroral oval and comparing the correlation between Kp and Bz values and the oval diameter. This is a statistical oval in which a majority of all the auroras occur. The oval is centered near the geomagnetic pole. Dr. Meng and Dr. Holzworth [1975] are two scientists who developed a mathematical representation of this oval (see figure 2). I later used this representation to help me in my project. The two indices I used to describe the placement of the aurora in comparison to the statistical oval were the Kp index and the Bz index. Although there are others, the Kp and Bz indices proved to be most useful. The Kp index is a three hour average while the Bz data used were one minute averages. The Bz is only a one minute average because the data the tracking stations receive are usually only a fifteen seconds long. The computers then averaged the data into one minute lengths. Ultimately, I compared each index with the oval diameter on graphs. My results were not surprising. The Bz index produced a cleaner graph. Points were plotted more accurately on the Bz graph than points on the Kp graph. One is not surprised by these results because by using a fifteen second average, one's data is not subject to any major discrepancies like the three hour averages. The time scale for auroral activity is less than three hours.

Unfortunately I soon learned that I would be doing a lot of preliminary work before I actually started the project. I began by using a program written by Israel Oznovich called Scene to reduce and analyze the data I had. The data had been collected at various stations around the world and stored on tape. Then the data would be transferred hour by hour onto disks. Using this program I would take the data from the disks and process it. The program would take the raw data through a series of steps and finally create an image of the aurora overlaid onto a geographical map (see figure 2a). After this process, I could take a polaroid picture of the screen for future comparison with other images from other times. At this point, I began to get a basic idea of what the aurora looked like from an ultraviolet view. I began to see general shapes of the aurora form.

The next step was to place the processed image into geomagnetic coordinates. This way I could get an idea of where the aurora was in comparison to the statistical model. I used a program called Aurplot that was just like Israel's except quicker. It allowed me to give the computer fewer commands and save time. After taking pictures of these images, I borrowed a cumbersome instrument called a zoom transfer scope. This scope overlays an image on a picture. I made a perfect circle and overlaid that circle onto the images I had previously photographed. Using the scope to maneuver the circle just so the edge of the circle was on the edge of the aurora in the picture, I was able to determine the diameter of the aurora in millimeters and degrees. I encountered a setback when overlaying the circle. I never established a center on the computer-created images. There was a good chance that the data would not be useful for my final results. Because the images were only about a quarter of the aurora, it made it extremely difficult to measure with any kind of precision. The image of the aurora was only a quarter of the entire aurora because there are not enough tracking stations to receive data from Polar BEAR. With the help of my mentor, Aurplot was modified so that it plotted the aurora in geomagnetic coordinates and put a red square at the center of the statistical oval of the overlaid image. This newly modified program was called Naurplot. The center was at 85.6 degrees latitude and 0.8 hours (Gassmann, 1973; Whalen, 1983). The center enabled me to attempt to measure the diameter with a little more accuracy and uniformity.

Next I used published tables of the Kp and Bz [NSSDC database] indices in order to find those values for the days I had processed. At this point I knew the diameter, Kp value, and Bz value for each pass. I created a file with this information and then moved it to the VAX computer (see table 1). Previously I had been using a Zenith model computer. Next I plotted this information on graphs of Bz v. diameter (see figure 3) and of Kp v. diameter (see figure 4). Of course the plot of the Bz values was more concise and accurate in comparison to the plot of the Kp values. This was because the Bz time intervals were shorter than those of Kp.

Not everything in this project went flawlessly. For example, it took me quite a while to process the data using Israel's program. It seemed that a new problem would arise just when I thought I had the program down perfectly. I also had trouble retrieving some of the data. Only a limited amount of data had been placed onto disk. Endless days of data was still on the data tapes. The real problem was figuring out what data on the tapes would be good enough for the project. Our possibilities for data were further reduced when we realized that data beyond day 60 in 1987 was most likely useless. At this time, the Polar Bear satellite had problems with its attitude control or stability. It rolled over a few times. It is extremely rare that a satellite will ever do that. We also had some problems with the programs a couple of times, but those were fixed with only a few modifications.

There were a lot of things I learned about working in research lab this summer. I learned that you should always try a test run with a small amount of data and run it all the way through your experiment. This way one can learn if there are any snags in the procedure that can be fixed then. One does not want to be placed in a situation where they have to modify and run through their entire project because they did not test it in the beginning. I also learned that the amount of data you start with will not always equal the amount of data you end up with. Through the procedure, data gets thrown out for a variety of reasons. You will most certainly end up with less data than you started with. Finally, I learned how much preliminary research one must conduct before he or she actually begins a project. I did about three to four weeks of preliminary research before I even began my project.

V. Conclusion

After six weeks of diligent hard work, I came to the end of my project. I had not realized was that I had formed my own statistical oval. At first I thought I had just been comparing Bz to Kp. I was wrong as my mentor pointed out. I had in fact did what Meng and Holzworth had done. My independent project really had no affect in determining how the Air Force could curb the problem with the aurora. As of now there really is not any applicable use for my research, but there may be a use for it in the future. I was given this project solely to get a feel for the aurora, computers, and what research is all about. I made plots of my research and began writing this final report. The end result of this project is that a new statistical oval has been created. I used the same principles that Meng and Holzworth used to form their mathematical representation. The only difference is the statistical oval was slightly different in size. The plots made are mathematical equations of the oval. The equation for the diagram of Bz versus the diameter is

$$Dia = A(0) + Bz * A(1). \quad (1)$$

$$A(0) = 0.4014728E+02$$

$$A(1) = -0.5661348E+00$$

The equation for the diagram of Kp*10 versus the diameter is

$$Dia = A(0) + Kp*10 * A(1). \quad (2)$$

$$A(0) = 0.3951357E+02$$

$$A(1) = 0.5228985E-01$$

I found the outside diameter of the oval by using selected data and their Bz values. However, I did not find the inner diameter of the oval. In comparison to Meng's and Holzworth's obtained data, I used data which had either much higher or much lower Bz values. The data I used were much more broader and produced a better graph. Meng and Holzworth used a lot of data where Bz was close to zero. This does not provide a diversified graph. In fact some of the data could even be called useless. That is why I selected my data. Beforehand I would look up the Bz values and pick out data with high and low values.

My data was also a combination of day and nighttime data. Meng's and Holzworth's data were entirely nighttime. As far as I can see, there are no extreme differences when using daytime and nighttime data. The end results are the same.

Thus one can conclude that the time of day really has no great impact on the measured diameter or at least that there were no systematic errors.

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Figure .

AIRS Satellite

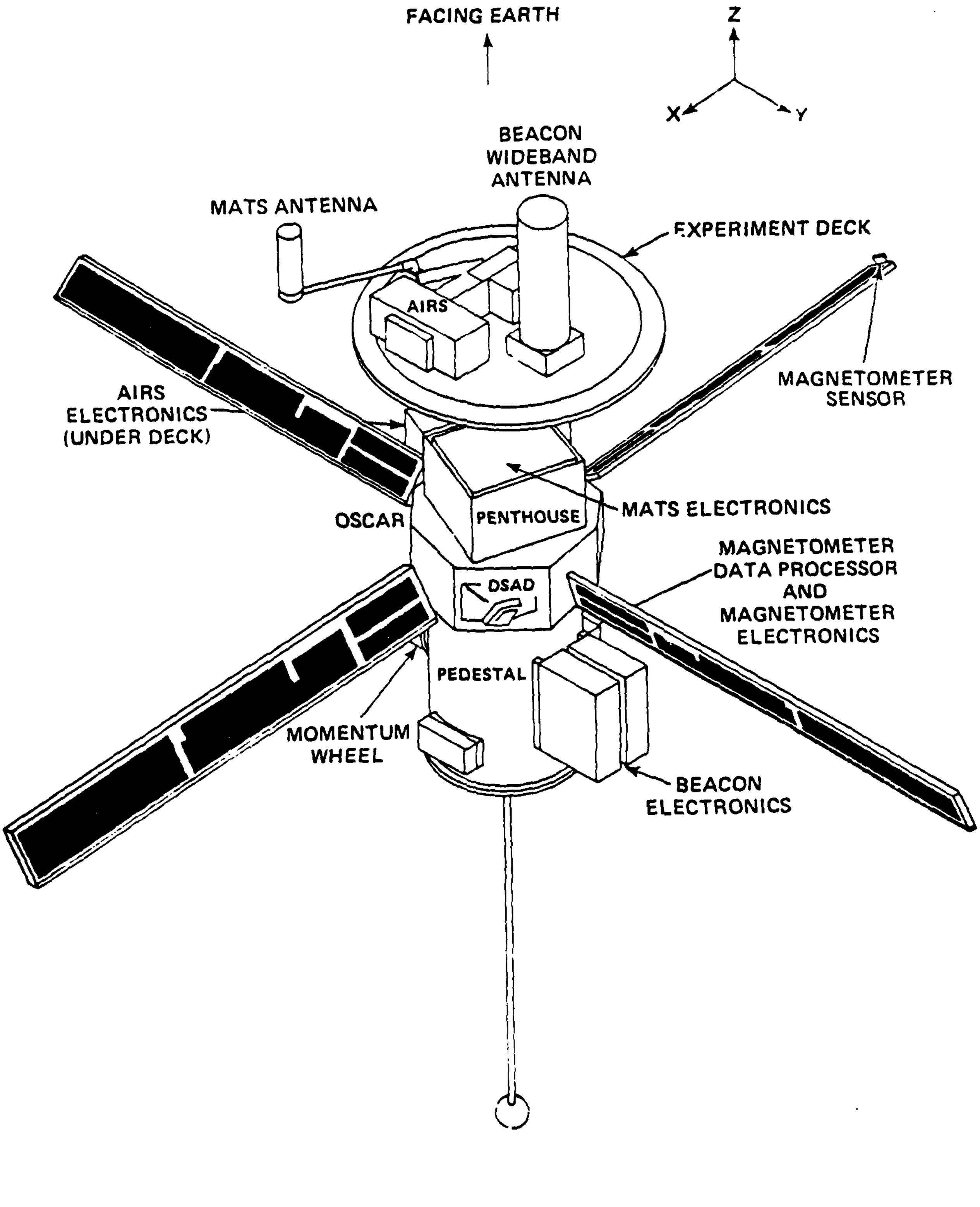


Figure 1A

Where one can most likely see an aurora...

Percentage of Nights on Which Aurora Is Expected

City	Percentage
Northern Hemisphere	
Barrow, Alaska	100
Churchill, Canada	100
Fairbanks, Alaska	90
Anchorage, Alaska	30
Winnipeg, Canada	20
Calgary, Canada	18
Montreal, Canada	10
Bangor, Maine	9
Buffalo, New York	6
Minneapolis, Minnesota	6
Boston, Massachusetts	5
Seattle, Washington	5
New York, New York	4
Chicago, Illinois	4
Washington, D. C.	3
Denver, Colorado	3
Atlanta, Georgia	1.5
San Francisco, California	1.5
Los Angeles, California	0.5
Houston, Texas	0.5
Mexico City, Mexico	~0.05
Tromso, Norway	90
Kiruna, Sweden	80
Oslo, Norway	10
Edinburgh, Scotland	8
Moscow, USSR	3
London, England,	2.5
Paris, France	1.5
Munich, Germany	1
Madrid, Spain	0.2
Rome, Italy	0.1
Tokyo, Japan	~0.01
Southern Hemisphere	
Melbourne, Australia	3
Sydney, Australia	1
Auckland, New Zealand	1
Capetown, South Africa	0.5
Rio de Janiero, Brazil	~0.01
Buenos Aires, Argentina	~0.01

Figure 2

A Mathematical Representation of the Auroral Oval
By Dr. Meng and Dr. Holzworth

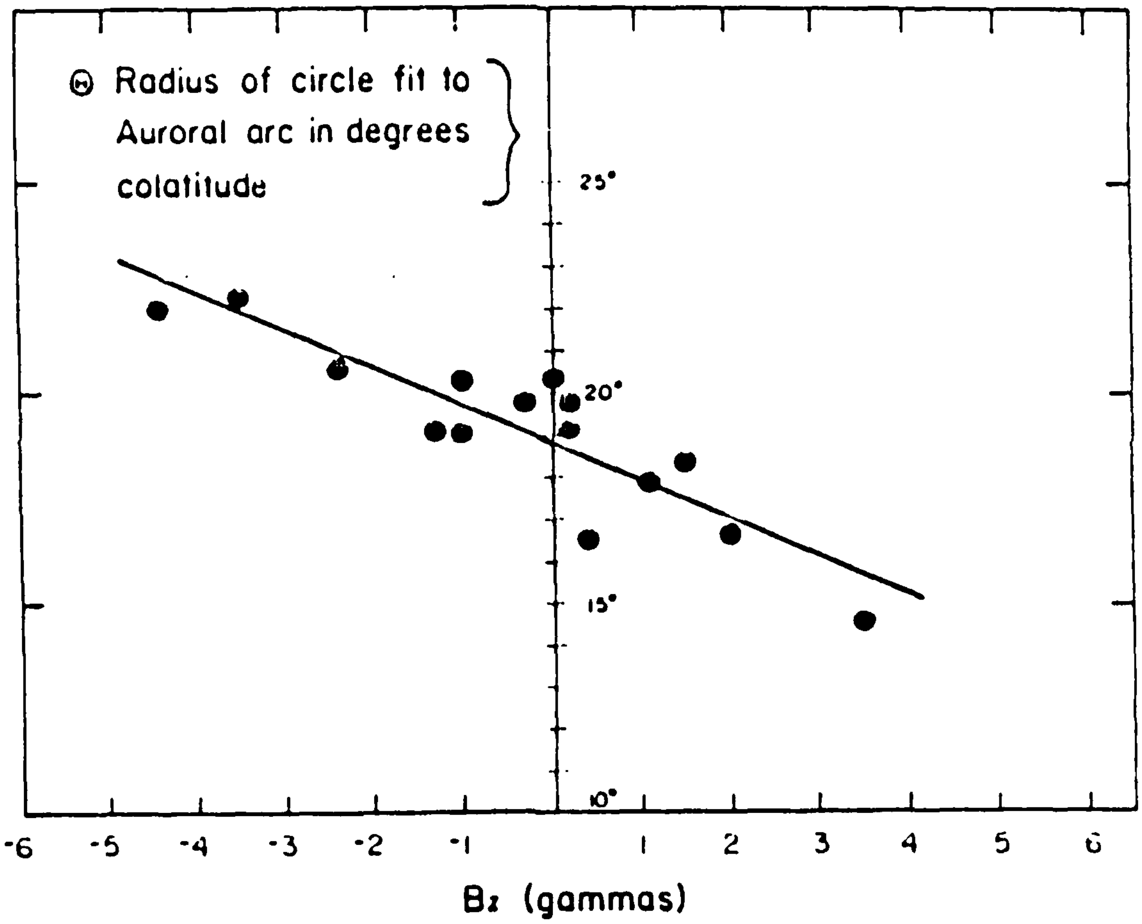


Table 1

DATA CHARTS FOR COMPARISON BETWEEN KP AND BZ VALUES

Date (*)	Time (UT)	Station	Diameter (Degrees)	Kp (*10)	Bz (Gammas)	Day/Night
87030	7:35-1:46	Sondre	36.21	17	2.2	No data
87037	7:01-7:12	Tromso	38.28	3	6.9	Day
87028	18:10-18:17	Tromso	41.38	30	5.5	Night
86365	14:52-15:03	Sondre	45.52	27	-3.4	Dusk
87025	4:21-4:32	Sondre	35.17	27	2.2	Night
87027	10:47-10:59	Tromso	44.48	30	-4.5	Day
86364	19:37-19:44	Sondre	43.45	23	-4.9	Day
86365	13:07-13:14	Sondre	42.41	27	-4.8	Day
87027	9:02-9:14	Tromso	41.38	30	-2.6	Day
87042	21:33-21:45	Tromso	37.24	17	4.4	Night
87050	22:03-22:15	Tromso	35.70	23	7.9	Night
87050	23:50-24:00	Tromso	33.10	23	9.1	Night
87027	10:47-10:59	Tromso	44.48	30	-4.3	Day
87055	19:17-19:29	Tromso	42.41	40	0.0	Night
87039	4:20-4:30	Sondre	39.31	33	0.0	Night
87043	13:31-13:43	Sondre	47.07	40	0.0	No data
87050	22:05-22:13	Sondre	37.24	23	0.0	No data
87029	2:49-3:02	Sondre	39.31	47	0.0	No data
87063	7:32-7:45	Rover	42.41	13	0.0	Dusk
87051	8:44-8:56	Tromso	46.03	40	0.0	Day
87015	15:19-15:32	Sondre	44.48	13	0.0	Day
87163	10:04-10:14	Tromso	44.48	0	0.0	Day

* Last two digits of year and the julian day make up the date.

Figure 3

Bz(Gamma) Versus Diameter in Degrees

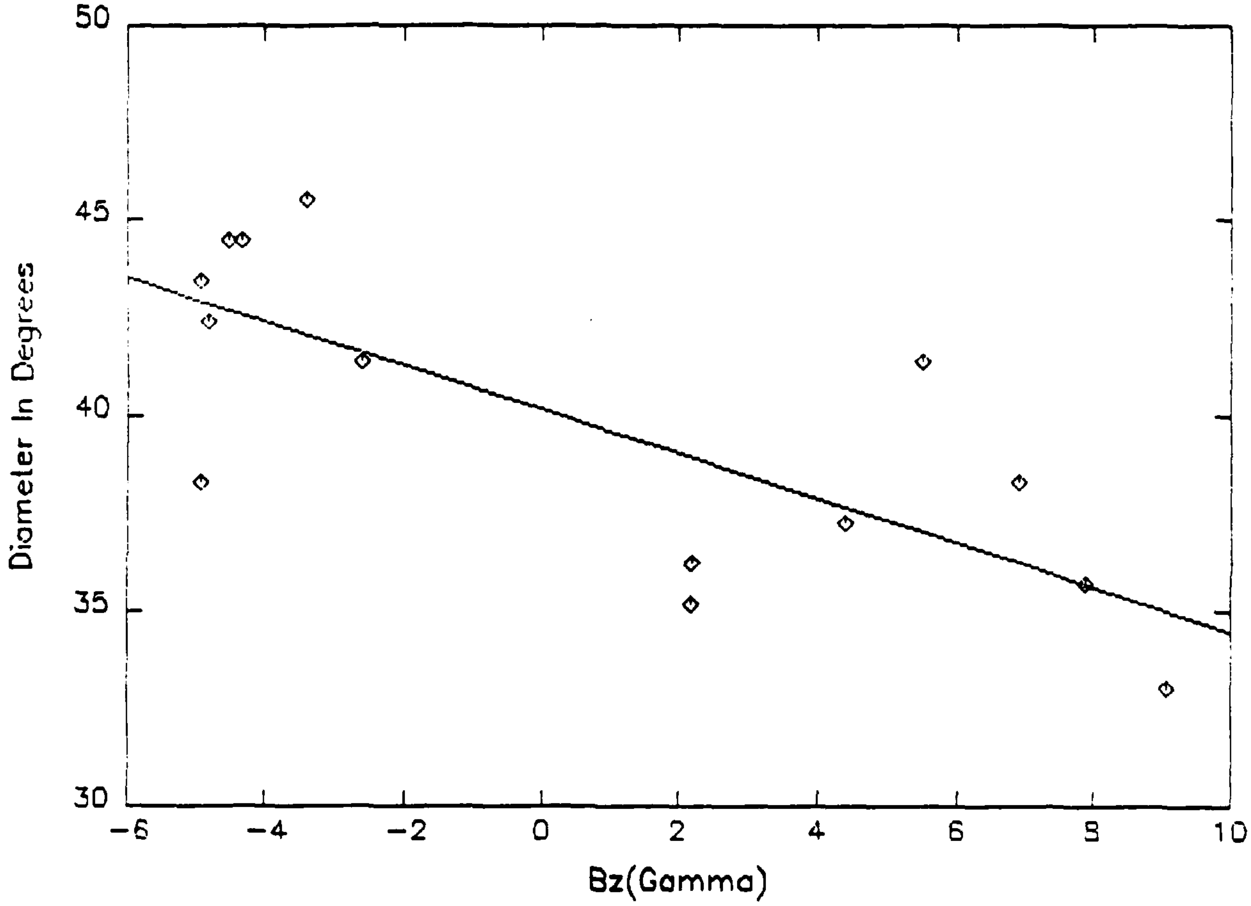
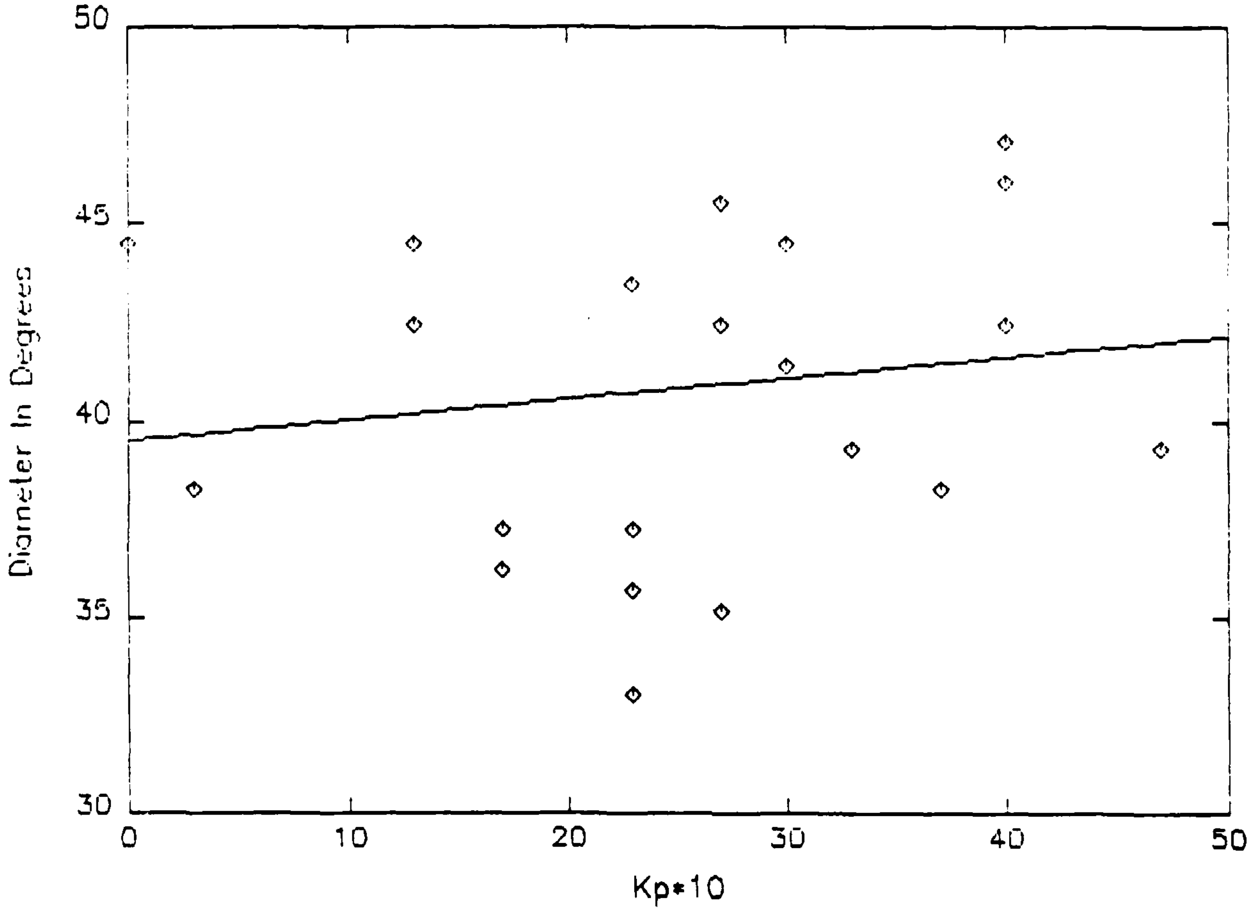


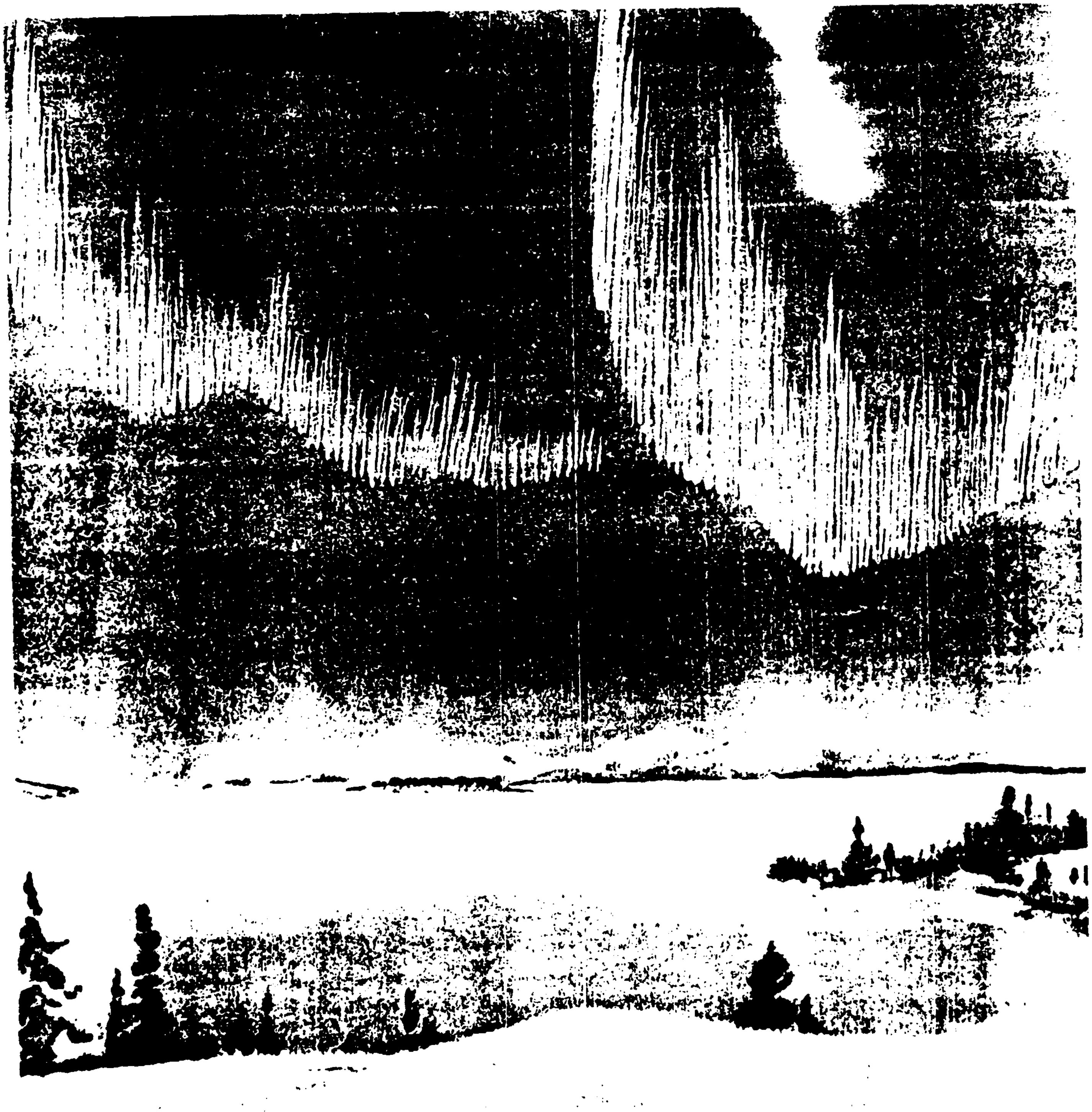
Figure 4

Kp*10 Versus Diameter in Degrees



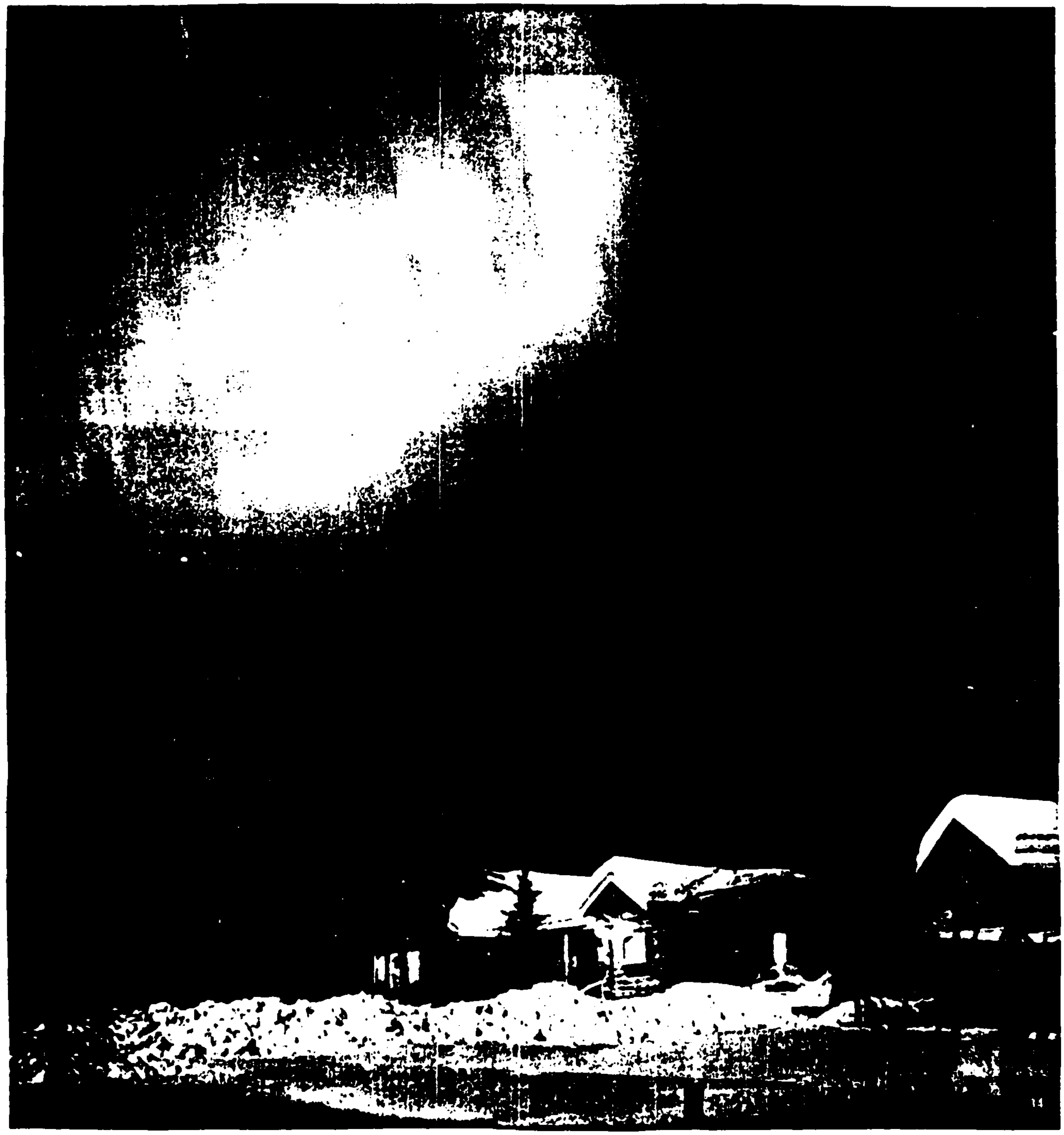
Example of an Aurora

Painting by Stephen Hamilton



Example of an Aurora

Near Fairbanks, Alaska



APPRENTICESHIP REPORT; OPTICAL PHYSICS LABORATORY

Christopher A Guild

Dr. Fred Volz

Air Force Geophysics Laboratory

August 25, 1989

ACKNOWLEDGMENT

I wish to thank Dr. Volz for sharing his knowledge of Optical Physics with me. I really did not know anything about this particular subject and it was pretty difficult understanding the technical vocabulary and other related terms. However, since I am planning a career as a scientist, I know how valuable it is to broaden my perspective in many areas.

I would also like to thank my family for giving me the support and encouragement I needed to succeed in this program, and especially my mother and father who helped my through the hardest of times.

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1. Introduction

   My intention to learn and experience aeronautical engineering;

   Now, some especially in aerosol science

2. Large Aerosols in the Atmosphere

   Aureole 1978-1980-1989

   Compare with dust collection 1989

   My task--collections and evaluation

   by microscope; also, size and kind of particles

3. Evaluation of Weather Data

4. Solar Radiation

   Sun Photometer

      Very hazy and clear samples

      Nomogram, computer

      Red lens extinction (would not be so with ice clouds) then green;

      water vapor

5. Mean of Smoke

   1. Transmission 5 filter

      soot, grass, fire, smoke, grease, cigar

   2. Quartz Crystal Microbalance

      Operation - crystal coating

6. Conclusion

1. Introduction

Just eight weeks ago, I entered the Geophysics Lab feeling somewhat overwhelmed, somewhat frightened, somewhat in awe, of the science program which would allow me to channel my raw curiosity into something organized and meaningful. The subject area would be one with which I was quite unfamiliar, but the experience gained would fuel my desire to investigate challenging, informative data in a scientific manner. As I became involved in my project over the summer, I realized even more importantly that my desire for a career in aeronautical engineering would take an enormous amount of discipline and hard work--and it would be well worth it.

The one month program was centered around the effects of large aerosol particles on the sun's aureole. During this time I collected, evaluated, and classed dust measurements. I also took solar measurements and learned to operate a light transmission photometer as well as a modern six channel aureole measuring device.

2. Large Aerosols in the Atmosphere

About fifteen to twenty years ago, large aerosol particles were abundant in the air. These aerosols present in the atmosphere produced a very strong glare at the sun's edge which was caused by the forward scattering of light. With the use of neutral density filters, you can view the aureole, 'glare free' (figure 1).

Readings were taken in the western part of Boston since 1973. Up to about 1979, it took a neutral density filter of 1.6 to suppress the glare.

But by 1983 and later, you could almost view the aureole without filters. This meant that the giant aerosols decline averaged out to about a factor of 10 over a ten year span. Presently, the neutral density filters average 0.6, although cases of very low readings (NDF=0) became sparse. But there are no indications saying that the neutral density filter readings are on the rise again.

So then, what was causing the decrease of neutral density filter readings? Dr. Volz decided, just two years ago, to continually measure the big aerosol particles found close to the surface and to relate them with simultaneous neutral density filter readings.

He suspected that pollen, dust, stellate hairs (found mostly on the bottom of oak leaves), and leaf filaments affected the sun's aureole. Dr. Volz realized that along with seasonal changes, pollen also changes, especially in the spring and summer months. So with the use and help of four instruments and one source of information, Dr. Volz bases his theory from the data collected in his twenty year study.

My main objective for the one month program working with Dr. Volz, was to collect big particles and to evaluate them. The aerosol impactor consisted of a 450 rpm motor, arm slide (3 mm wide), coated plexiglass slide, and usually a one hour timer. We try to keep a sample going for one hour because a longer time is usually not necessary. Particles which are smaller than an 8 radius escaped the impactor's arm.

The aerosol impactor collector was located on top of the five story high Air Force Geophysics Lab roof on the western side.

Everyday, except when it rained, we put up a collection from about 10 to 12, and from about 1 to 3 (two samples a day). When it rains, most of the pollen gets 'washed out' of the air. So taking a sample during a rainstorm would be useless and the rain itself could ruin the electrical equipment.

We tried to keep the sample going for at least one hour, but if it ran longer, we could easily adjust the data with the use of a slideruler. Along with the taking of the pollen sample, we would also, before and after this was done, note what kinds of clouds were in the area, wind speed and direction, and record sun data with the use of a photometer and neutral density filters. Some but not all of this data went towards proving his theory.

Within the last three weeks of the program, I started taking pollen samples at my house in West Newton. Dr. Volz needed some readings close to Boston because he wanted to see how much more pollen, dust, stars, and filaments were in the air in comparison to the Bedford/Lexington counts. In order to get the best readings, I placed the pollen impactor on our $1\frac{1}{2}$ story garage. The nearest house to the impactor was at least 25 feet away. This allows ample room to get accurate readings of air.

The rotating dust collector (figure 2) was constructed by Dr. Volz to collect airborne particles above a $5\mu m$ radius. Smaller and lighter ones would go around the slides as does the air (figure 2.1). It consisted of a synchronis motor with a 16" arm rotating at 450 rpm (20 km/hr). On the long end of the arm can be inserted a 3 mm wide sliver of hard plastic. On the shorter end, weights can be added to balance the longer arm for smooth running.

Pollen slide counting was my main task. It requires a lot of time and patience on the microscope. But since I have had a lot of experience with microscopes in school, it took me less than a day to be able to distinguish the pollen from the dust.

At a magnitude of 12 X 8, I counted particles between 5 and 20μm radius (small) and 20 to 100μm (large). Proper lighting for counting was achieved by using incandescent light, beaming down sideways onto the s ides. In this way, cratering of the coating by impacted particles was much less of a problem than using transmitted light. However, black roundish particles with jagged edges (from car tires!) were easier to see in the transmitted light.

The slides, which were evaluated, covered sections of a whole year. In winter, dust particles were predominant. In April and May, pollen were also present, sometimes in large numbers. Pollen from oak, birch, elm, and pine are rounded or football shaped.

Later, very large pine and spruce pollen were present. Also counted were stellate hairs, long thin fibers which came from the young leaves of some kinds of oaks. A sample of microphotographs I made is shown as figure 3.

Grass pollen is the true football shaped pollen (figure 3.1). Dust, on the other hand, follows no specific pattern or form. Each has their very own shape, size, and color. No two dusts are exactly alike in any way (figure 3.2).

Stellate hairs resemble starfish (figure 3.3). Leaf filaments or leaf hairs resemble a hair. Their sizes range from 15μm to 50μm .

Some things startled me while I was observing and counting. I found bug parts on some slides and even a bug attempting to get itself out of the grease! There were also black particles scattered over most of the slides. As previously mentioned, these particles were from the tires of cars. (figure 3.4) Their sizes ranged from 15μm to 70μm. Even more surprising was that in the readings I had taken in West Newton, car tire particles were in quantities twice the amount found in the Bedford/Lexington readings.

Ascension Island was a volcanic island. Slides from that island showed that the volcanic dust was laden with sea salt. Counting of the dust was only possible after careful washing of the slides. I was surprised to see some pollen, which apparently was from the local sparse grass.

Related to the slide evaluation was the entry of the particle count into a data file. With weather permitting, the file also contained data on the turbidity of the atmosphere and the aureole brightness. Computer programs produced plots of particle measurements (per m^3, figure 4). Also, the count was weighed for the effect of the different measured aerosol particles on the aureole which was correlated to aureole brightness. A linear relationship is indeed indicated, even though the useful range of neutral density filters was from 0.1 to 0.6 only.

3. Evaluation of Weather Data

In continuation of the work done by last year's summer intern , I evaluated wind speeds measured at Hanscom Field and at Concord, New Hampshire separately for fair and cloudy days (rainy days were left out) between 1982 and 1986.

The daily 7 a.m. wind data showed an effect on the winds during 1983, possibly caused by volcanic dust in the upper air (previously detected for Worcester Airport).

4. Solar Radiation

Sun photometers are used for instantaneous handheld measurements of direct solar radiation for determination of aerosol extinction and precipitable water. When taking a sample, one should take it on a clear day or in the morning before the haze sets in (not a true reading if taken through haze). The detectors are a red lens (would not be so with ice crystals), green lens, and a water vapor extinction lens. Data from these instruments went on to a computer program and were plotted.

5. Mean of Smoke

The smoke box and 5 filter instrument measured the amount of transmitted light through smoke (figure 5). The filter wheel consisted of a 1.6, .8, red, green and ultraviolet filters which was connected to a graph plotter to record the readings. Soot, grass, grease, and cigar smoke was produced while I was there. All of this information was put on to a computer and was plotted in this manner (figure 5.1).

The Quartz Crystal Microbalance recorded the amount of particles impacted on to quartz crystals. The reading was possible from a led readout.

As air would enter the top of the 6 stack system, it was drawn into each stage. As the air went from top to bottom it sped up. This action caused smaller and smaller particles to impact (figure 6).

Cigar smoke was introduced to the machine in diluted form because it could saturate the crystals and cause the readings to be distorted. Only after a while did the reading go up. Outside air was also used but little results were achieved. All this data was put on to a computer program and plotted.

In conclusion, the pollen/aureole theory did not work out as well as Dr. Volz expected. The data from both sides did not match up. As far as he was concerned, there was no real connection with all of the data. Further studies would be conducted to determine if indeed, there was a connection at all.

The eight week program turned out to be an invaluable stepping block to my scientific future. The experience that I gained by working with Dr. Volz has expanded my desire to achieve unexplored higher goals and standards. I realize now just how difficult it is to be a scientist and how much discipline and hard work it takes--and I am willing to sacrifice my time to prepare myself for a future in science.

Apprendices can be obtained from

Universal Energy Systems, Inc.

Universal Energy Systems, Inc.
Air Force Office of Scientist Research
1989 USAF-UES High School Apprenticeship Program
Final Report

Ionosphere - Total Electron Content

Prepared by: Maki Inada
Research Location: Ionospheric Physics Division,
Air Force Geophysics Laboratory,
Hanscom Air Force Base
USAF Mentor: Gregory Bishop
Date: August 8, 1989

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II. Introduction

The Geophysics Laboratory is a research facility sponsored by the Air Force located at Hanscom Air Force Base. The scientists here engage in research ranging from earth sciences at ground level to space physics in outer space. This summer I worked in the Ionospheric Effects Branch, part of the Ionospheric Physics Division, which deals with many aspects of the ionosphere such as: ion, electron and neutral particle densities, velocities and temperatures; the theory of solar-ionospheric interactions and functions; and the study of the auroral oval.

The ionosphere is a partly ionized region of the atmosphere which exists high above the earth's surface (See Figure 1). It ranges from about 50 to 1000 km in altitude, but the region of greatest electron density is approximately 300 to 350 km (See Figure 2). The existence of the ionosphere is mostly due to the ionization of upper atmosphere atoms by solar ultraviolet to near x-ray radiation. The group whose work I participated in this summer focused on a particular measure of ionospheric activity called Total Electron Content (TEC).

WHAT IS THE IONOSPHERE?

- PARTLY ($\approx$ 5%) IONIZED REGION OF THE UPPER ATMOSPHERE
  ALTITUDE: 50 TO 1000 KM
  PEAK DENSITY OF IONS: $\approx 5 \times 10^{11}/M^3$ @ $\approx$ 300 KM
  BELOW PEAK: HIGHER ATMO. DENSITY → GREATER COMBINATION
  ABOVE PEAK: LOWER ATMO. DENSITY → FEWER IONS PRODUCED

- ELECTRONS ARE THE CONTRIBUTORS TO RF EFFECTS (IONS TOO HEAVY)

- MAJORITY OF INTEGRATED ELECTRON CONTENT AT PEAK ± 50 KM

Figure 1. Description of the Ionosphere

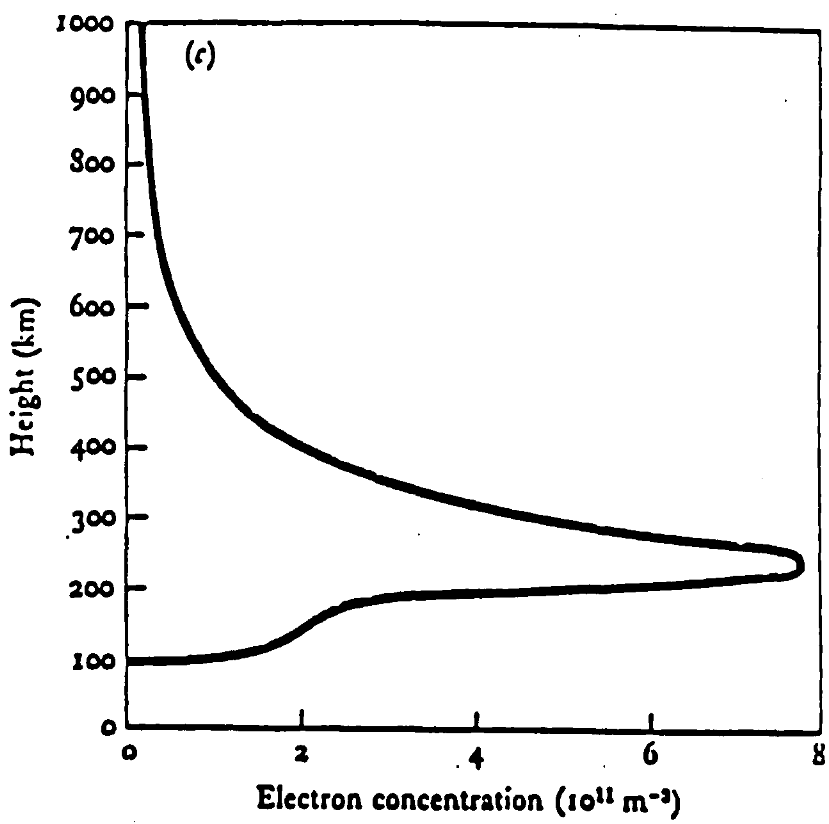


Figure 2. Typical Electron Density Profile of the Ionosphere

III. Description of Research

A. Project One

Total Electron Content (TEC) is the number of free electrons in the ionosphere along the line of sight between a satellite and a user location. The ionosphere is far from constant. TEC varies in a complex manner with the time of day, the time of year, geographic location, and the state of solar and magnetic activity (See Figure 3). TEC measurements recorded at many geographic locations around the world are being analyzed.

Analysis on several years of data was performed using a CDC Cyber 860 mainframe computer and a Zenith 248 PC-compatible microcomputer. Files containing a year of daily data (15 minute values) were processed to monthly files to be plotted for analysis. Observed data entry errors were corrected using the Cyber text editors, Neted and Xedit. Statistics were then generated from the newly corrected data.

Figure 5 is an illustration of TEC dependance on time of day, season, and solar sunspot conditions. TEC has a daily cycle which reaches its peak in the early afternoon and its minimum just before dawn, because ionization is dependant on solar radiation (See Figure 4). Observation has shown that TEC curves form one general shape in the spring-summer period, a different shape in fall-winter and high variability shapes during equinoxes.

Since 1979 was a high sunspot activity year, higher TEC values were recorded as opposed to 1975, a low sunspot year, with lower TEC values (See Figure 7).

Figure 6 is a sample of the monthly statistics that were generated for all the analyzed data. The statistics consist of means, standard deviations, minimums, maximums, and various percentiles. The results of this study will be used to test several ionospheric models that predict TEC. They will also be used to further study the variation of TEC at different times, geographic locations, and solar conditions.

B. Project Two

My second project also dealt with the behavior of the ionosphere and TEC. The study of TEC is valuable for determining the effects of the ionosphere on radio/radar transmission and reception. One example is Over-The-Horizon (OTH) radar which uses the ionosphere to bounce signals over the curvature of the earth. Another example is Ground-Based radars used to track space vehicles, which can experience range errors related to TEC.

TEC is measured by the use of signals from the Global Positioning Satellite system (GPS) measured by ground receiver systems located at varying sites around the world. The GPS satellites are a system put into space by the US Air Force for air and ground navigation. The ground receiver systems receive and process signals transmitted from the GPS satellites. The reciever system, which consists of an

HOW DOES THE IONOSPHERE BEHAVE?

- DAILY CYCLE: PEAK IN AFTERNOON
  MIN AT NIGHT

- ANNUAL CYCLE

- SUNSPOT CYCLE

- GEOGRAPHIC REGIONS

- MAGNETIC STORMS

Figure 3. Parameters Characterizing Ionospheric Variation

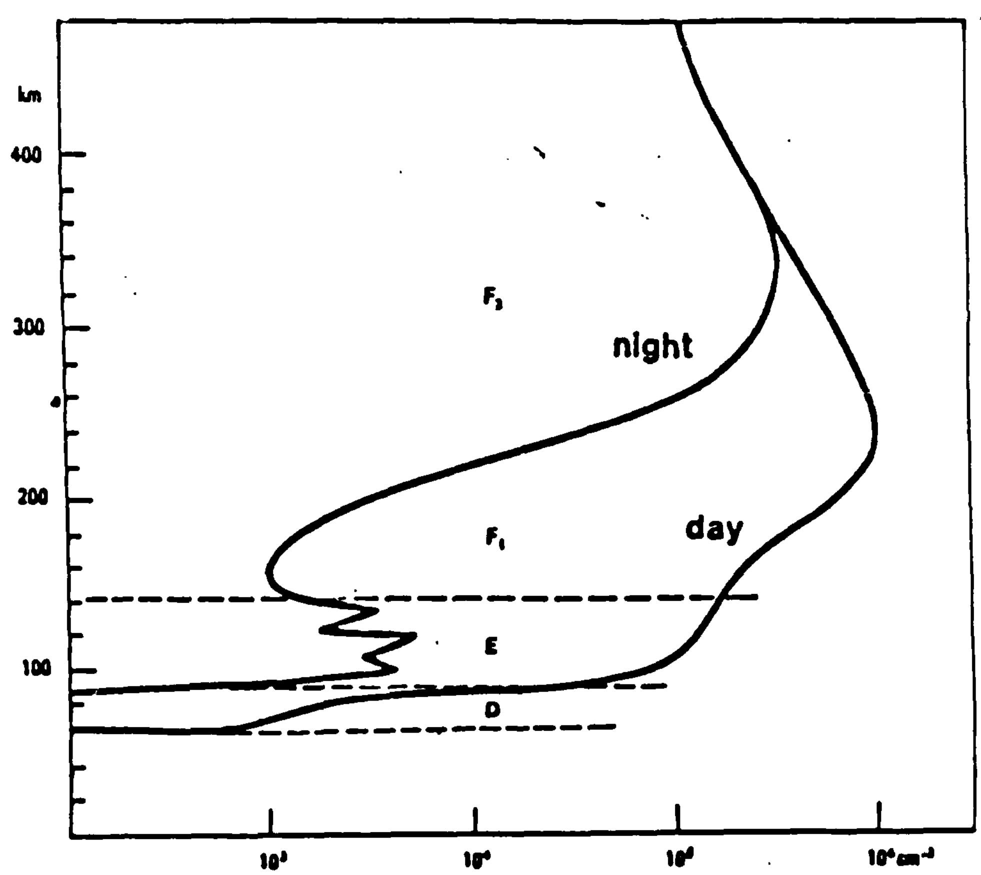


Figure 4. Typical Diurnal Variation in Ionospheric Electron Density Profile

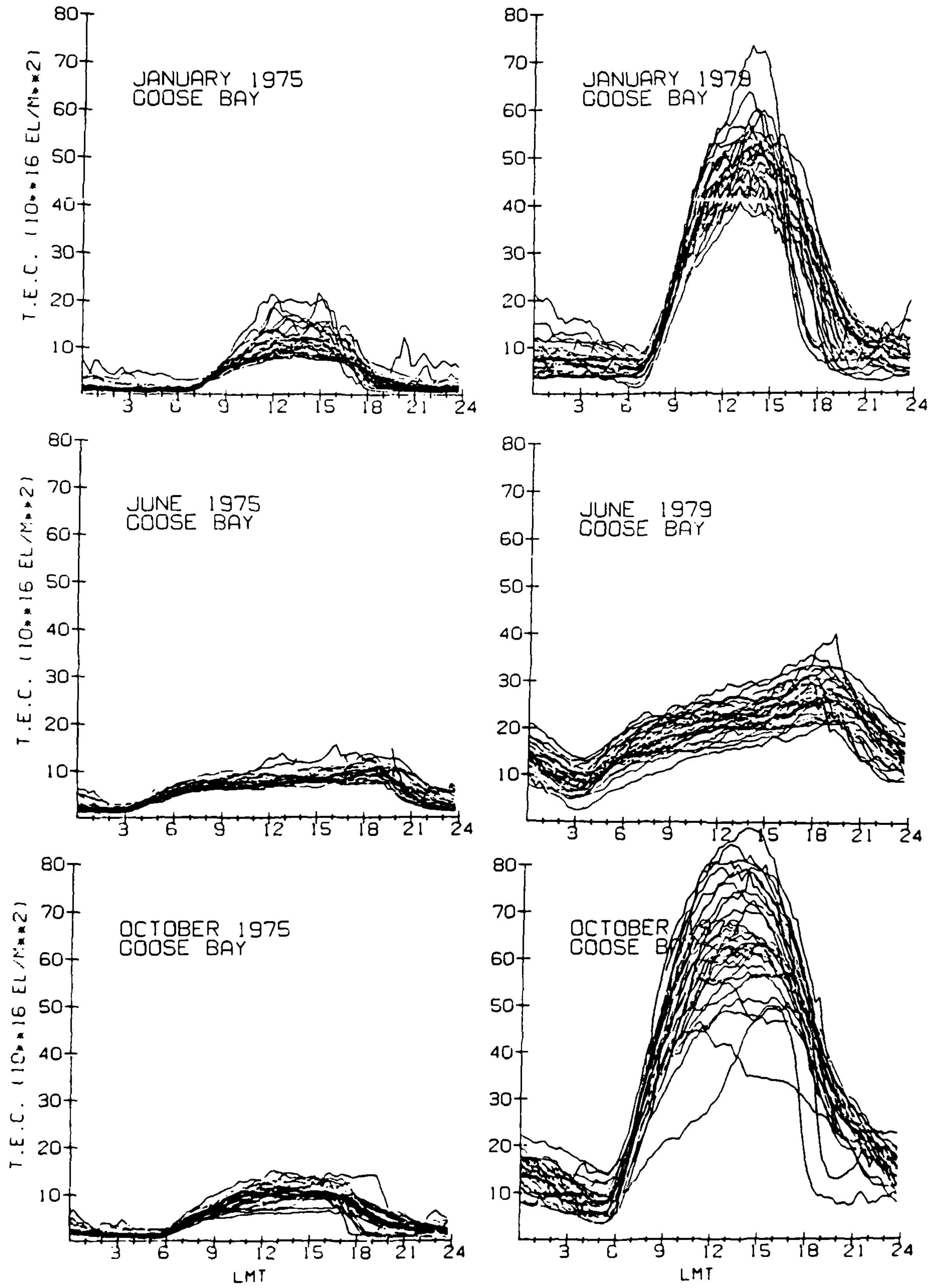

JANUARY 1975
GOOSE BAY
JANUARY 1979
GOOSE BAY
JUNE 1975
GOOSE BAY
JUNE 1979
GOOSE BAY
OCTOBER 1975
GOOSE BAY
OCTOBER
GOOSE B
T.E.C. (10**16 EL/M**2)
LMT
0 10 20 30 40 50 60 70 80
3 6 9 12 15 18 21 24

Fig. 5 TEC

[illegible]

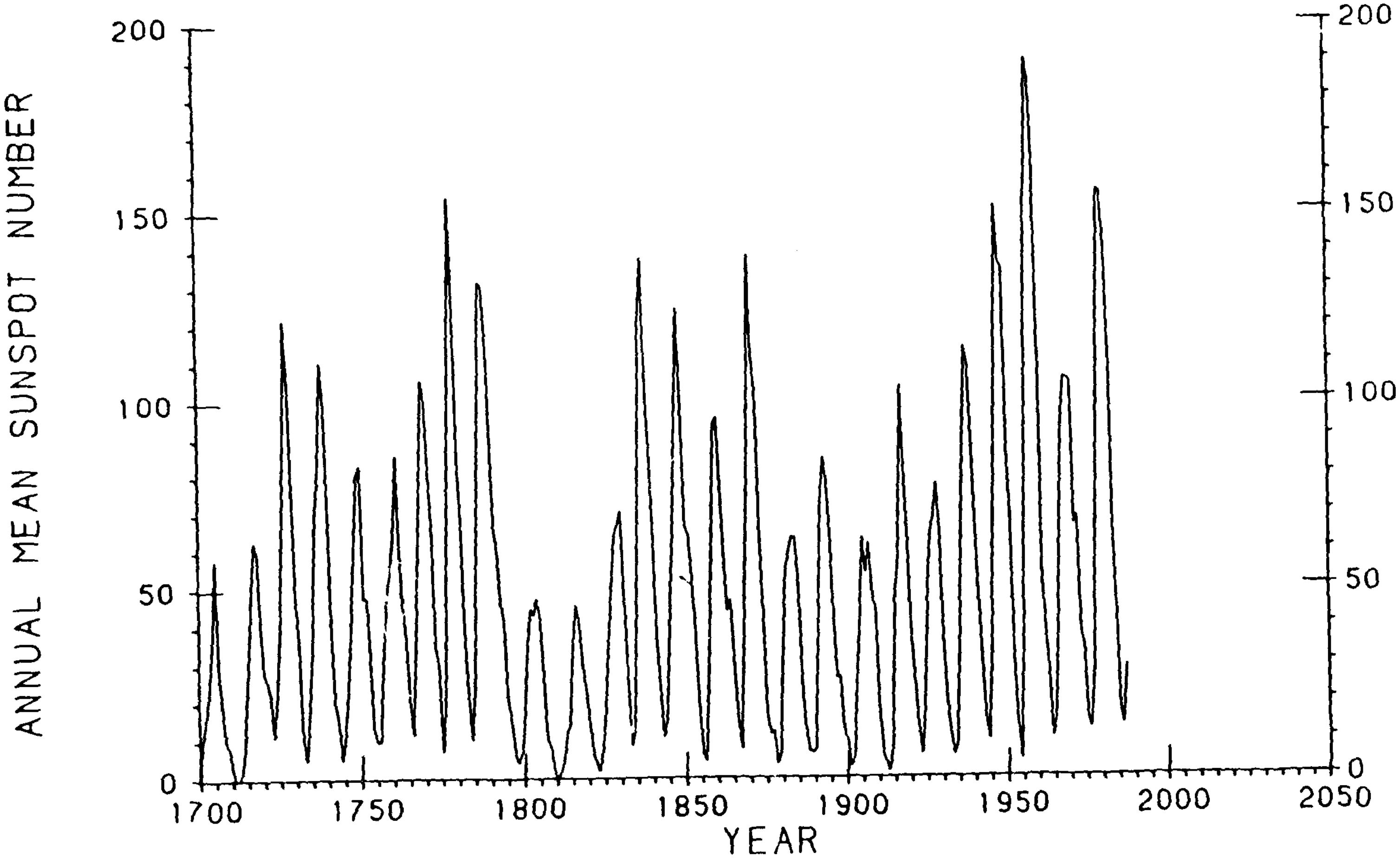
HOURLY VALUES OF TOTAL ELECTRON CONTENT VS. LMT (UNITS ARE IN ELECTRONS/SQ METER*10**15)

OCTOBER 1979

DAY	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	[illegible]	9.1	7.9	5.1	[illegible]	5.4	9.5	15.4	[illegible]	31.1	36.7	43.0	45.8	48.6	47.9	47.2	45.5	45.9	41.4	33.1	27.0	24.7	21.2	18.7
2	15.9	15.4	13.4	11.2	5.6	7.3	11.4	[illegible]	29.4	37.6	41.6	46.9	[illegible]	55.7	59.2	62.9	52.4	56.3	50.7	38.7	31.2	25.7	20.7	16.1
3	14.3	14.2	[illegible]	10.4	[illegible]	[illegible]	17.9	23.2	33.7	42.5	46.7	45.7	50.3	52.4	55.0	56.0	53.0	49.0	44.3	38.1	30.5	24.5	22.7	20.3
4	17.4	15.7	[illegible]	9.4	6.3	7.9	11.0	21.2	29.9	38.7	43.9	44.5	46.3	49.5	50.4	53.5	51.3	46.8	40.4	32.5	26.8	23.2	20.9	19.0
5	17.3	[illegible]	13.7	12.5	10.9	9.3	13.7	22.8	29.1	42.4	47.3	51.2	55.2	58.0	59.3	60.5	57.4	52.6	46.0	38.6	32.3	28.2	22.9	18.3
6	13.6	13.7	14.1	13.9	[illegible]	14.7	14.5	21.6	[illegible]	39.5	39.5	45.3	42.1	41.3	35.9	34.4	31.8	32.8	29.4	26.3	22.7	21.0	20.9	19.2
7	17.3	13.3	[illegible]	9.9	5.9	7.6	13.5	21.7	31.8	42.8	55.1	57.2	59.3	54.7	49.3	46.9	49.2	48.8	41.3	17.3	12.7	15.0	15.1	16.5
8	[illegible]	13.4	9.5	9.1	11.9	3.3	13.7	12.2	15.9	20.6	21.3	25.0	28.7	34.7	42.9	47.8	43.5	42.9	13.7	9.3	7.4	7.6	7.4	9.2
9	[illegible]	9.7	11.4	9.2	7.3	9.2	11.3	17.4	29.9	36.4	42.7	50.7	60.1	62.6	52.5	60.0	56.0	52.5	40.4	29.9	23.2	18.8	13.1	10.5
10	[illegible]	7.2	9.1	9.1	7.6	7.2	15.8	22.3	29.2	43.2	51.2	55.3	54.3	55.5	55.9	55.9	55.0	50.5	43.8	32.4	23.7	19.2	17.0	14.8
11	[illegible]	10.5	[illegible]	8.2	[illegible]	5.9	13.5	21.4	53.0	43.9	50.3	59.3	64.5	67.5	55.6	52.9	59.8	55.7	48.5	37.9	30.0	24.7	21.5	19.2
12	17.5	17.2	14.3	12.9	11.3	9.4	12.5	22.2	32.4	43.8	51.1	57.7	62.5	53.6	63.9	63.4	60.3	56.9	51.7	38.4	29.7	23.7	23.8	17.5
13	12.0	[illegible]	9.9	8.2	6.9	6.9	10.4	21.6	34.3	45.0	55.4	39.7	59.2	58.6	53.5	58.2	55.1	55.9	48.0	36.1	28.3	23.1	19.4	15.1
14	13.3	13.2	12.5	9.7						35.0	43.9	52.5	58.0	50.3	52.8	62.5	58.4	52.8	45.1	34.8	27.7	23.0	19.2	15.6
15	15.9	15.6	11.8	9.7	7.7	5.9	[illegible]	21.5	31.9	42.3	47.3	52.7	54.1	50.7	61.9	60.3	56.5	54.6	49.9	39.4	30.0	23.2	19.3	15.1
16	[illegible]	7.6	6.5	5.5	4.5	3.7	[illegible]	15.6	27.5	38.7	47.1	54.3	65.1	52.3	60.3	60.6	60.6	55.9	50.3	38.6	28.5	23.0	20.3	17.1
17	19.6	13.2	11.5	9.7	4.5	3.1	12.5	23.4	36.2	50.7	[illegible]	53.9	64.2	64.1	63.2	63.9	61.2	53.6	46.8	38.2	30.1	24.7	21.1	19.6
18	[illegible]	15.5	13.3	12.9	[illegible]	4.2	[illegible]	22.3	35.0	43.9	57.6	61.5	64.2	65.8	65.3	64.2	61.2	53.5	46.2	36.0	28.2	23.4	22.3	19.2
19	15.1	13.2	9.5	8.1	6.2	[illegible]	[illegible]	23.9	[illegible]	42.4	32.7	59.3	65.1	72.9	74.1	72.1	65.6	59.3	50.1	37.9	29.2	24.8	22.6	20.9
20	[illegible]	17.2	11.7	9.0	5.5	[illegible]	[illegible]	23.9	[illegible]	48.2	56.4	67.0	69.5	72.9	74.2	78.4	75.3	65.0	53.6	40.2	32.8	28.4	23.7	20.0
21	17.0	17.4	[illegible]	13.7	11.5	[illegible]	[illegible]		29.6	59.4	64.0	76.5	71.6	80.4	[illegible]	78.7	71.7	66.3	52.8	35.0	26.1	22.4	17.3	14.4
22	[illegible]	12.2	9.2	5.7	6.3	[illegible]	7.0	23.0	27.1	51.9	65.0	75.7	81.9	84.8	87.6	86.0	77.5	68.5	58.0	43.7	30.2	26.5	20.5	13.9
23	[illegible]	11.4	9.5	7.5	6.1	[illegible]	[illegible]	21.9	27.2	52.0				80.9	79.0	73.4	67.4	58.8	48.0	29.8	21.2	19.2	18.6	15.8
24	9.4	7.5	7.5	5.7	5.9	5.7	5.4	20.1	34.4	49.9	55.3	76.0	80.2	84.2	80.5	78.5	73.6	64.5	53.3	40.7	32.6	27.8	22.8	19.5
25	[illegible]	13.2	11.2	10.1	9.9	7.4	9.3	21.0	36.4	51.5	[illegible]	71.5	74.0	75.8	72.1	69.4	65.2	59.1	48.2	39.9	30.9	25.0	21.7	16.5
26	15.4	17.0	16.7	13.9	13.3	12.2				57.2	67.0	73.8	73.0	77.1	78.7	75.0	71.5	64.1	52.6	39.3	32.2	27.8	24.0	21.3
27	17.4	13.5	10.0	11.8	11.9	12.1	14.0	23.2	30.4	52.7	52.5	68.9	73.5	77.4	77.9	76.2	70.5	64.4	54.0	42.4	34.4	29.8	24.3	22.2
28	[illegible]	23.5	19.5	16.4	16.7	14.4	13.0	25.6	41.4	48.0	[illegible]	63.0	62.2	62.7	61.3	63.0	61.8	55.8	47.3	37.7	22.2	20.5	18.8	13.5
29	13.5	14.7	14.5	13.4	9.7	6.3	5.5	14.1	23.1	34.4	47.2	55.4	61.0	54.3	70.7	70.7	57.8	60.7	50.6	38.3	24.9	18.5	12.7	11.2
30	11.3	9.2	9.2	11.3	11.3	9.2	10.6	21.7	37.8	47.2	56.7	53.5	65.6	69.3	70.0	69.3	63.5	57.5	46.6	36.7	28.4	23.5	20.3	17.5
31	17.0	15.9	14.3	13.0	12.3	10.9	10.1	19.1	32.2	45.1	56.5	63.5	70.2	74.9	77.1	75.7	59.4	60.7	52.2	40.5				
MEAN	14.5	13.2	11.4	10.9	9.3	[illegible]	10.5	23.7	32.8	44.1	47.1	58.2	61.6	64.3	64.7	64.0	61.2	55.6	46.7	35.3	27.2	23.0	19.7	17.0
S.D.	3.3	3.4	3.0	2.9	2.0	2.0	2.6	2.9	5.3	7.9	10.4	11.4	12.0	12.2	12.0	11.4	9.4	7.5	7.9	7.1	5.8	4.4	3.7	3.2
%S.D.	22.4	[illegible]	27.3	26.0	32.5	34.2	25.6	14.0	15.1	17.4	19.9	19.5	19.5	19.0	18.6	17.3	15.4	13.5	17.0	20.0	21.3	19.2	18.8	18.6
MIN	[illegible]	7.2	6.3	[illegible]	[illegible]	3.2	[illegible]	12.2	15.9	20.6	21.3	25.0	28.7	34.7	35.9	34.4	31.8	32.8	13.7	9.3	7.4	7.6	7.4	9.2
MAX	[illegible]	23.5	19.5	16.4	16.7	14.7	15.8	25.6	41.4	59.4	65.0	76.5	81.9	84.8	87.6	86.0	77.5	68.5	58.0	43.7	34.4	29.8	24.3	22.2
10.PCT	[illegible]	7.5	7.4	5.1	[illegible]	[illegible]	7.2	15.4	22.1	34.4	39.5	[illegible]	[illegible]	48.6	47.9	47.2	49.2	45.9	40.4	26.3	21.2	18.5	13.1	11.2
25.PCT	[illegible]	10.4	[illegible]	6.2	[illegible]	5.9	[illegible]	20.1	29.4	38.7	47.1	51.7	55.2	55.7	[illegible]	58.2	56.1	52.5	44.3	33.1	24.9	21.0	18.6	15.1
50.PCT	[illegible]	13.3	11.3	9.9	[illegible]	7.4	11.5	21.6	[illegible]	43.8	51.2	57.7	61.0	63.6	63.2	63.0	61.2	55.9	48.0	37.9	28.4	23.4	20.7	17.1
75.PCT	17.0	15.5	13.7	12.5	11.3	[illegible]	11.9	22.2	[illegible]	43.9	53.4	65.1	[illegible]	72.9	74.1	72.1	67.4	59.3	50.7	38.7	30.8	25.0	22.3	19.2
90.PCT	[illegible]	17.6	14.5	13.9	12.3	12.1	14.7	23.2	36.2	52.0	55.0	73.5	74.0	80.4	79.0	78.4	71.7	64.5	53.3	40.5	32.3	27.8	22.9	20.3
COUNT	31	31	31	31	29	30	29	29	29	31	30	30	30	31	31	31	31	31	31	31	30	30	30	30

Fig. 6 Statistics

75-9



MEAN YEARLY SUNSPOT NUMBERS SINCE 1700

Fig. 7

75-10

antenna, chart recorder, tape system and DEC pdp-11 minicomputer produces chart records and signal values converted to digital quantities that are stored on tapes. Thule, Greenland and Roy-Namour of the Kwajalein Islands are some sources of data. Another site is now being developed in the Shetland Islands, Great Britain. My work was with data from Thule. The tapes and charts recorded at the sites are sent to the Geophysics Lab for processing and analysis.

Processing begins by studying the chart records of the quantities measured and stored on the tapes. Currently, the magnitude and frequency of ionospheric disturbance is of particular interest. Differential Carrier Phase, refered to as 'doppler', is the parameter that I studied (See Figure 8a and 8b). It provides a very precise measure of variations in TEC. The chart records of 'doppler' activity are examined and tabulated according to a 'quick-look' scaling method (disturbance activity valued from 1 to 6) developed to identify periods of interesting or high activity (See Figure 9a and 9b). The interesting intervals are correlated to individual files on the tapes, known as 'pass files', because they relate to the signals received from a satellite as it passes overhead. Due to the large volume of tapes received, the interesting 'pass files' are combined onto separate tapes to facilitate or speed-up processing. These tapes are processed overnight (a typical tape takes 6-8 hours to run) on a high-speed mainframe computer, the CDC Cyber. The processing routine converts the raw data to various signal TEC measurements and stores the data on another tape for plotting and analysis.

Table: Activity quantifier for GPS and 250 MHz beacon data.

		GPS	250 MHz Beacon	Comment
Quiet	1	< 0.5 TEC u/10 min	SI > 2dB	No detectable activity.
Small	2	< 0.5 TEC u/ 5 min	2 < SI < 4dB	Detectable TEC variation, detectable scintillation.
Moderate	3	< 1.0 TEC u/ 5 min	5 < SI < 9dB	Smooth rolling structures.
Disturbed	4	< 1.0 TEC u/30 sec	10 < SI < 15db	Sharp, short gradients.
Very Disturbed	5	> 1.0 TEC u/30 sec	SI > 15dB	Very sharp, sustained gradients.
Extremely Disturbed	6	> > 1.0 TEC u/30 sec		Extremely large gradients.

Fig. 9a Quick Look Scale

HIGH ELEVATION

LOCATION: AFGL/LIS
DAY : 282
DATE : 08
MONTH : OCT
YEAR : 1988

	GPS	244	AZ	EL		
HOURS	ACTIVITY					
0000-0100	1	1-3				
0100-0200	1-2	1-2				
0200-0300	2	2-4				
0300-0400	1	3				
0400-0500	1	3-4				
0500-0600	1	1-3				
0600-0700	1	1				
0700-0800	1	1				
0800-0900	3-4	2-4				
0900-1000	2-3	2-3				
1000-1100	—	1				
1100-1200	– 1	1				
1200-1300	2-3	2-3				
1300-1400	4	3				
1400-1500	6	5				
1500-1600	5	5				
1600-1700	5	2-5				
1700-1800	2-3	2-5				
1800-1900	4	2-4				
1900-2000	4	2-4				
2000-2100	3-4	2				
2100-2200	3-4	2-5				
2200-2300	2-3	2-3				
2300-2400	1-2	3-4				

ACTIVITY SCALE
1 = QUIET
2 = SMALL
3 = MODERATE
4 = DISTURBED
5 = VERY DISTURBED
6 = EXTREME

Fig. 9b Quick Look Tabulation from Chart Records

Initial analysis consists of plotting the 'doppler' data (See Figure 10a). If the data is very interesting another plotting routine is run with the 'doppler' data, the azimuth and elevation of the satellite (to illustrate potential effects of signal direction and location of the activity), a complex algorithm determining significant activity and curves of probabilities of the various levels of activity (See Figure 10b). Along with this plot, tables of different activity level probabilities are created.

The next step in the analysis process is to enter the newly obtained information into a database. This database is created using Ashton-Tate's DbaseIII-Plus on the Zenith 248. The fields of the database consist of the data filenames, the period covered by the 'pass file', various quantities relating to sunspot activity and the tables of probability created in the previous step (See Figure 11).

While I did not participate in these next steps, I was informed that programs will be run on the database files that analyze for correlations between solar activity and the ionospheric distubances recorded. The results will be written into a report to be used by scientific- or application-oriented interested parties or to be published in a professional journal.

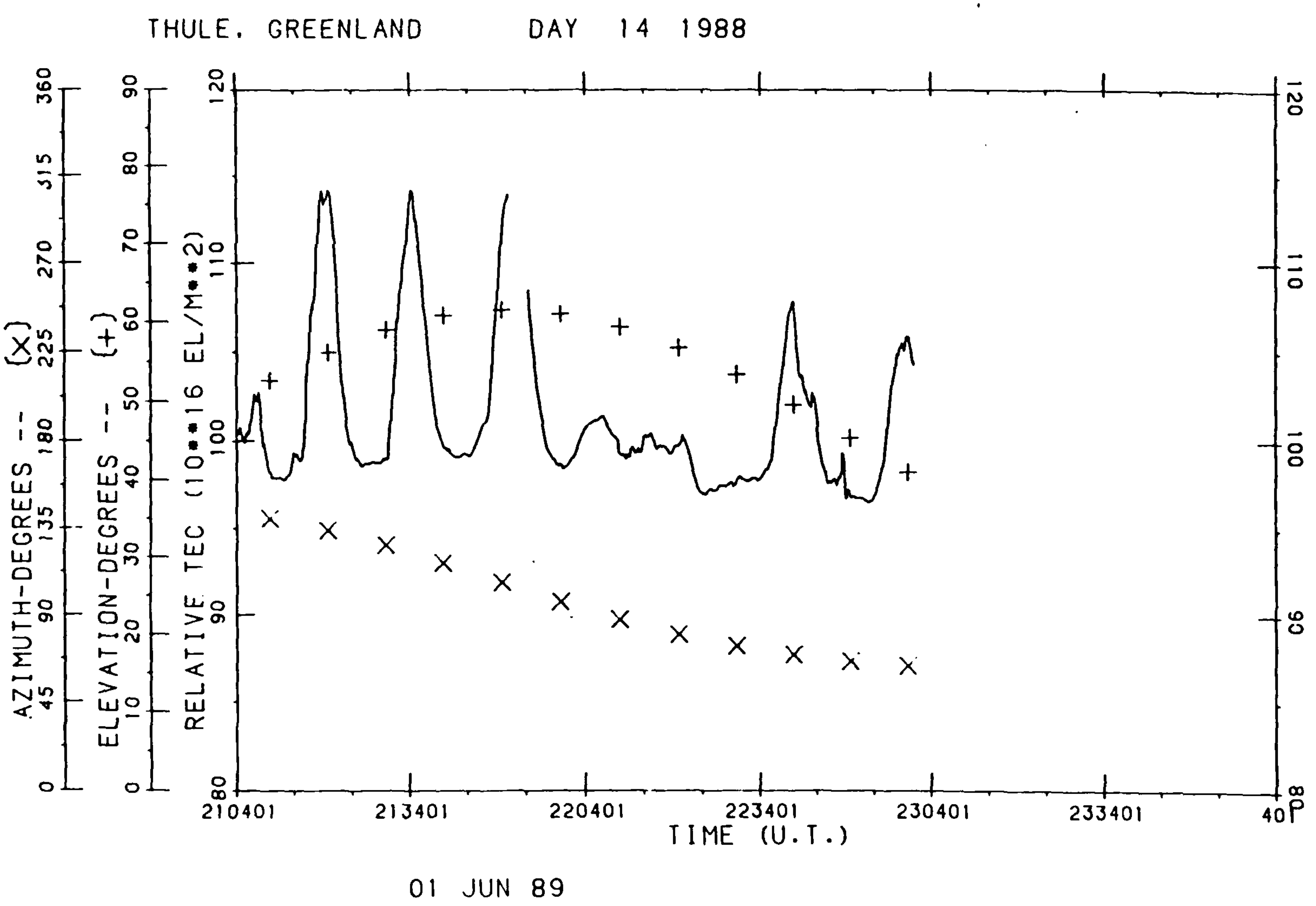


Fig. 11a Doppler Plot

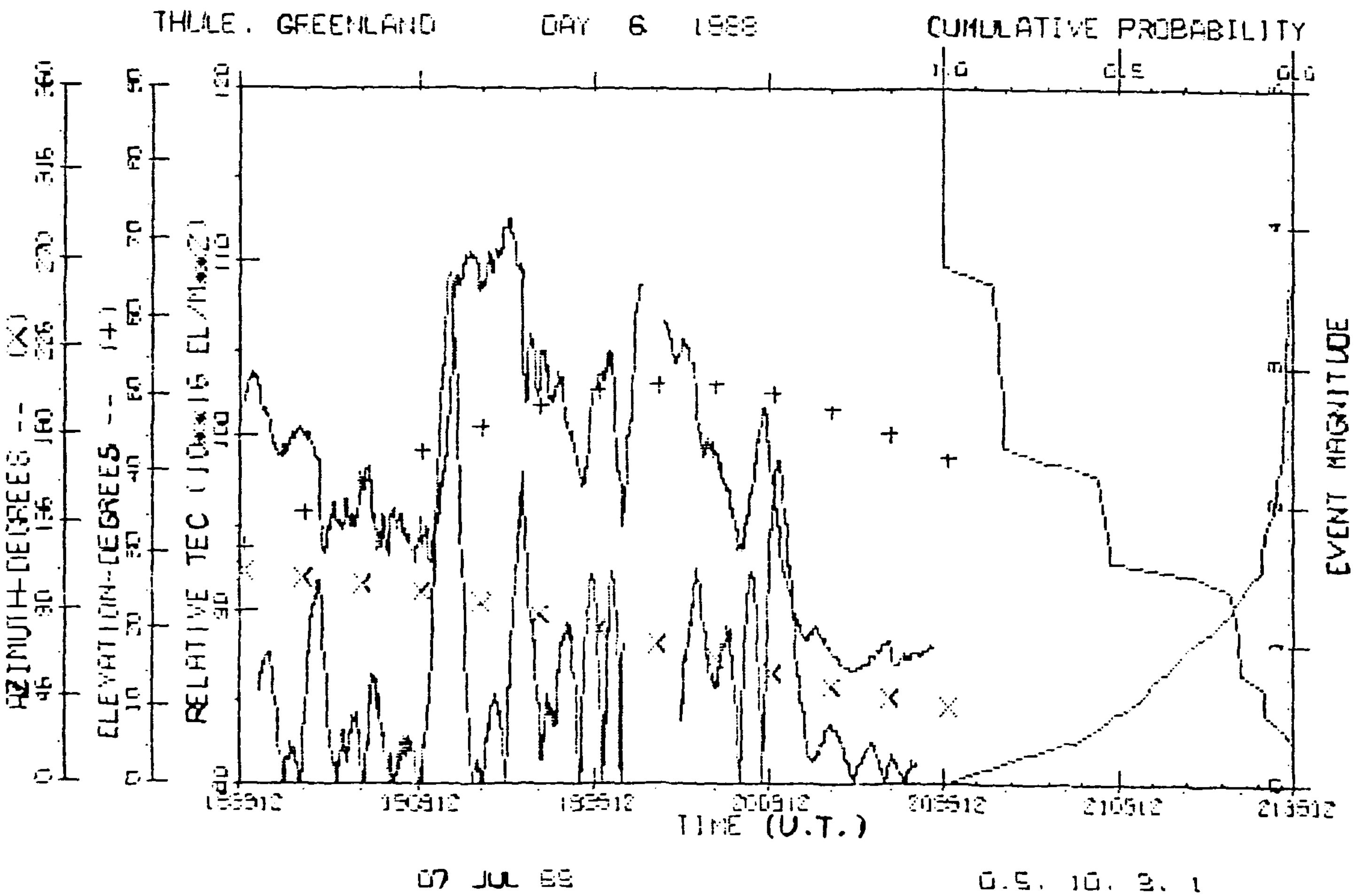


Fig. 106 Complex Doppler Plot

Fig. 11 Sample Page of Selected Fields

Page No. 1
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THULE GPS TEC STUDY DATABASE
Part 1

REC ID	SUN SPT NUM	RAD FLX	MD-LAT MAG-DX A-INDX	MD-LAT MAG-DX K-INDX	HI-LAT MAG-DX A-INDX	HI-LAT MAG-DX K-INDX	FDB 1	FDB 2	FDB 3	PROB01	PROB02
1	66	95	10	2	7	2	0	0	0	0	0
2	78	93	9	3	5	3	0	0	0	179	565
3	78	93	9	3	5	2	5	10	10	0	0
4	78	93	9	3	5	1	0	0	5	0	0
5	106	106	30	5	23	4	5	5	10	0	281
6	89	107	21	5	19	6	5	0	0	0	0
7	89	107	21	3	19	3	5	5	10	3	418
8	96	101	9	2	6	2	0	0	[illegible]	0	0
9	91	97	12	3	7	2	5	5	5	0	0
10	91	97	12	3	7	2	5	5	5	0	0
11	91	97	12	4	7	3	0	0	0	0	193
12	69	90	20	4	12	2	5	5	10	0	0
13	0	0	0	0	0	0	-1	-1	-1	0	0
14	72	107	28	3	23	4	0	0	0	0	418
15	72	107	28	4	23	4	0	0	0	0	1347
16	72	107	28	5	23	4	5	5	10	0	107
17	72	107	28	5	23	4	5	5	10	0	141
18	66	100	32	5	22	4	-1	-1	-1	0	0
19	66	100	32	5	22	3	-1	-1	-1	0	0
20	61	105	10	3	7	3	-1	-1	-1	0	0
21	59	101	12	3	8	2	-1	-1	-1	0	0
22	59	101	12	3	8	3	-1	-1	-1	0	0
23	43	96	8	2	4	1	-1	-1	-1	0	0
24	54	92	13	2	8	2	-1	-1	-1	0	0
25	54	92	13	2	8	2	-1	-1	-1	0	0
26	54	92	13	3	8	2	-1	-1	-1	0	0
27	54	92	13	5	8	3	-1	-1	-1	0	0
28	59	91	18	2	13	1	-1	-1	-1	0	0
29	59	91	18	2	13	2	-1	-1	-1	0	0
30	51	95	21	2	14	3	5	5	5	0	0
31	51	95	21	4	14	3	10	10	10	0	0
32	21	94	23	4	23	4	10	10	15	0	220
33	21	94	23	3	23	3	5	5	10	0	0
34	23	96	14	3	10	3	0	0	5	0	0
35	58	115	15	3	9	2	10	10	15	0	220
36	58	115	15	3	9	3	5	10	10	0	8
37	58	115	15	2	9	2	5	10	10	34	1014
38	123	118	47	6	91	8	5	5	10	0	0
39	123	118	47	6	91	8	5	5	5	0	147
40	71	112	37	6	42	7	0	0	0	0	189
41	71	112	37	4	42	6	5	5	5	0	0
42	71	112	37	4	42	6	5	5	5	0	0
43	71	112	37	4	42	5	0	0	0	0	912
44	57	98	34	4	24	5	5	5	5	0	0
45	57	98	34	4	24	4	5	5	5	0	0
46	57	98	4	4	24	3	0	0	5	0	0
47	38	95	13	2	8	2	0	0	0	0	233
48	38	95	13	2	8	2	0	0	0	0	0
51	38	95	13	2	8	1	-1	-1	-1	0	0

IV. Bibliography

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Klein, Michael J. and C. Charley Andreasen, "Studies of Ionospheric Electron Content Variaions", NorthWest Research Associates, Inc. Technical Report, June 1989, Air Force Geophysics Laboratory, Hanscom AFB, MA.

Klein, Michael J., C. Charley Andreasen and John M. Lansinger, "Transionospheric Scintillation and TEC Studies", NorthWest Research Associates, Inc. Technical Report, December 1988, Air Force Geophysics Laboratory, Hanscom AFB, MA.

FINAL REPORT
by
Susan Jacavanco
Mentor: Peggy Shea
Hanscom Air Force Base Geophysics Laboratory
August 8,1989

I. ACKNOWLEDGEMENTS:

I would like to thank Peggy Shea, my mentor, for taking a part in this program and allowing me to experience as much as I have this summer. I thank Don Smart for teaching me about solar flares and the impact they have on the earth. I thank Louise Gentile for keeping me busy with ground level event data. I am also very grateful to Kathleen Sullivan and Nicholas Vickers for helping me when I had any questions.

II. GENERAL DESCRIPTION OF RESEARCH:

I worked in the Geophysics Laboratory at Hanscom Air Force Base this summer in the Space Particles Environment Branch. It was my second year as an apprentice in this division. In this department there are many projects going on all of the time. I was able to take part in a few of these projects. One of the major projects that I continued to help out with is the preservation of GLE Data in a computerized data base. The goal is to have all of the Neutron Monitor Data in a standard format so it is available for analysis. Thirty-nine ground level events (GLE) have occured from February 1942 to February 1984. An event occurs when there is an increase in the number of solar neutron particles. This is measured by neutron monitors that are located at different stations all over the world.

Another project I took part in was entering sunspot data from 1947 to 1964. A sunspot is an area on the photosphere of the sun that appears as a dark spot. They are dark because they are cooler than their surroundings. Last year I also entered sunspot data on the computer. This year the information was obtained from a Japanese scientist who observed sunspots from 1947 untill 1984. She published a book of this data.

In addition, I entered data from Mount Washington on cosmic ray intensity. This was plotted to show the mean cosmic ray intensity between 1954 and 1989.

III. DETAILED DESCRPTION OF RESEARCH:

A. Ground Level Event Data

1. The first step in processing Ground Level Event Data is to xerox each station listing for the whole event and highlight important information. Included in each complete set of data are raw neutron monitor counts, pressure data, and neutron monitor counts corrected for pressure. This does not mean that each station sends a complete set. Some stations have only pressures and corrected hourly counts while others may include only pressures. An example of highlighted data and an explanation of the differences in uncorrected and corrected counts can be found on tables 1,2, and 3. Notice that the station name is circled, the type of data is circled, the days needed to be entered are underlined, and the column number is labeled. Sometimes the highlighted event is sent down to a data entry person while other times we enter it ourselves.

2. The computer that this GLE data base is being set up on is a CDCC CYBER 750. The terminal I used was an IBM PC which was hooked up to the cyber through a network. I created a file for each station from the standard mask file

and used the full screen editor to modify the station name and dates. Then I entered the data into the correct columns. After I completed entering all of the data I printed out the file and proofread it. After making all of the necessary corrections, the data are ready to be processed using computer programs written by Louise Gentile. First, a header is merged with the file so it is in the correct format. This is an E-file. Then a program is run to transfer the hourly counting rates to counts per second. This is seen in the C-file. The same program calculates the percent of increase of each value from the interval before the event. This interval is called the baseline. These increases are plotted. The three steps of this procedure, the E-file, the C-file, and the plot can be seen on tables 4,5 and 6.

3. This year I also helped find many mistakes in the catalog of GLE data. I searched for errors in the station information like longitude, latitude, and standard pressure. In addition, I took care of recently received data that needed to be xeroxed.

B. SUNSPOT DATA:

1. To prepare for data entry I copied all of the information from the Japanese tapes. I then entered the data and corrected it. It was then ready for the computer program.

2. Louise Gentile plotted the points to graph a comparison of the sunspot number in the north to the sunspot number in the south between 1947 and 1984. Table 7 shows a picture of a sunspot and table 8 shows a graph of the Koyama sunspot data .

C. MOUNT WASHINGTON DATA:

1. This data entry was similar to the sunspot data entry. I entered the data for cosmic ray intensity from the year 1954 to the year 1989. I then proofread it.

2. Again, Louise plotted the points and came up with a graph to show the intensity. Table 9 shows this graph.

IV. RESULTS:

The ground level event project is not finished. Last summer events 26-39 were entered and processed. This summer events 19-25 were entered and processed. Hopefully, it will end soon and there will be a standard computerized data base for all GLE data.

Both the sunspot data and the Mount Washington data will be useful to researchers. The Mount Washington graph gives an overview of the cosmic ray intensity for 35 years. The sunspot data from Koyama can be compared to other stations.

V. OTHER INTERESTING OBSERVATIONS AND LESSONS LEARNED FROM SUMMER EXPERIENCE:

Everything I learned last year was reinforced during this summer at AFGL. This year I was able to visit the University of New Hampshire in Durham and see a neutron monitor. After working with the data for two summers it was nice to see where it all comes from.

VI. BIBLIOGRAPHY:

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NEUTRON INTENSITY MONITOR DATA. NOT CORRECTED FOR AIR PRESSURE VARIATIONS.

INSTITUTION MAX PLANCK INSTITUT FUER PHYSIK UND ASTROPHYSIK, GERMANY
STATIONN ZUGSPITZE ALTITUDE 2960 METER
GEOGRAPHIC LATITUDE 47.42 DGR. LONGITUDE 10.98 DGR.
GEOMAGNETIC LATITUDE 47.90 DGR. LONGITUDE 93.75 DGR.
BIHOURLY SUM OF THE A AND B SECTION. SCALING FACTOR 100
MEAN STATION PRESSURE 530 TORR. BAROMETER COEFFICIENT -1.05 PERC./TORR

NOVEMBER 1977 UT END OF INTERVAL

DAY	2	4	6	8	10	12	14	16	18	20	22	24	MEAN
1	5056	5090	5109	5127	5112	5112	5109	5075	5029	5011	5019	5050	5074
2	5051	5047	5062	5058	5090	5121	5101	5098	5047	5015	4981	4972	5053
3	4973	4952	4976	5003	4943	4993	4973	4985	4958	4963	4927	4947	4966
4	4958	4995	5022	5066	5062	5070	5073	5084	5064	5031	5022	4996	5035
5	5011	5016	5026	5038	5029	5025	5039	5025	5004	4993	4960	4978	5011
6	4999	5019	5037	5027	5022	5020	5051	4999	4963	4916	4911	4891	4987
7	4904	4914	4914	4926	4872	4875	4872	4861	4808	4782	4758	4762	4854
8	4753	4788	4804	4786	4770	4769	4777	4750	4737	4728	4671	4678	4751
9	4682	4682	4723	4689	4685	4727	4696	4701	4698	4683	4651	4645	[illegible]
10	4651	4651	4659	4666	4678	4665	4704	4698	4650	4594	4608	4613	4653
11	4610	4603	4620	4638	4631	4646	4569	4652	4659	4566	4574	4703	4548
12	4716	4801	4876	4936	4976	5043	5071	5123	5187	5227	5225	5258	5035
13	5308	5348	5382	5393	5444	5524	5624	5660	5684	5656	5553	5541	5509
14	5528	5516	5506	5542	5643	5599	5649	5656	5641	5671	5653	5667	5605
15	5711	5756	5718	5720	5733	5774	5800	5795	5778	5796	5798	5826	5767
16	5850	5888	5857	5865	5874	5899	5914	5879	5860	5850	5874	5895	5875
17	5951	5980	6022	5996	5966	5950	5906	5870	5821	5785	5787	5752	5898
18	5726	5707	5684	5664	5643	5589	5593	5571	5539	5502	5457	5434	5592
19	5414	5397	5381	5345	5334	5317	5311	5292	5263	5268	5277	5298	5324
20	5313	5320	5347	5354	5370	5413	5443	5498	5509	5548	5573	5579	5439
21	5623.	5668.	5721.	5788.	5856.	5879.	5871.	5874.	5891.	5915.	5935.	5930.	~~5829~~
22	59[illegible].	5890.	5836.	5802.	5738.	5783.	5680.	5639.	5586.	5563.	5521.	5490.	~~5709~~
23	5470	5437	5447	5403	5353	5330	5309	5272	5229	5200	5198	5234	5324
24	5234	5278	5316	5356	5357	5384	5435	5485	5488	5505	5533	5548	541[illegible]
25	5558	5582	5591	5565	5523	5531	5548	5497	5539	5612	5662	5598	5575
26	5686	5707	5736	5757	5777	58[illegible]	5764	5723	5643	5627	5650	5631	5708
27	5624	5606	5579	5590	5572	5560	5543	5513	5483	5432	5423	5402	5527
28	5390	5381	5389	5352	5351	5359	5372	5353	5319	5312	5290	5315	5348
29	5296	5329	5332	5317	5307	5309	5318	5324	5334	5308	5311	5284	5314
30	5288	5280	5292	5333	5346	5385	5397	5346	5322	5304	532[illegible]	5324	5328

I MEASUREMENTS INCOMPLETE. LESS THAN TWO HOURS OR ONE SECTION ONLY
E ESTIMATED VALUE. NO MEASUREMENTS

Col 48

Table 1

AIR PRESSURE IN TORR

INSTITUTION MAX PLANCK INSTITUT FUER PHYSIK UND ASTROPHYSIK, GERMANY
STATION ZUGSPITZE ALTITUDE 2960 METER
GEOGRAPHIC LATITUDE 47.42 DGR. LONGITUDE 10.98 DGR.
GEOMAGNETIC LATITUDE 47.90 DGR. LONGITUDE 93.75 DGR.
MEAN STATION PRESSURE 530 TORR. BAROMETER COEFFICIENT -1.05 PERC./TORR

NOVEMBER 1977 UT END OF INTERVAL

Co 56

DAY	2	4	6	8	10	12	14	16	18	20	22	24	MEAN
1	531.0	530.3	530.0	530.1	530.5	530.6	530.8	531.1	531.7	531.9	531.8	531.4	531.0
2	531.3	531.4	531.2	531.4	531.3	530.8	530.2	530.4	530.8	531.0	531.0	531.6	531.0
3	531.7	531.8	531.5	532.0	532.7	533.1	533.2	533.2	533.0	532.9	533.3	533.0	532.6
4	532.6	532.2	531.9	531.8	532.0	532.0	531.7	531.8	532.1	532.6	532.9	533.1	532.2
5	533.0	533.0	533.3	533.7	533.9	533.8	533.7	533.8	533.9	533.9	534.0	534.0	533.7
6	533.8	533.6	533.5	533.6	533.8	533.7	533.7	533.9	534.3	534.7	535.0	535.2	534.1
7	535.4	535.6	535.9	536.4	536.9	537.2	537.2	537.3	537.7	538.1	538.4	538.5	537.1
8	538.5	538.4	538.3	538.7	539.0	539.0	538.9	538.8	539.2	539.4	539.7	539.9	539.0
9	540.0	539.8	539.8	540.0	540.3	540.2	539.9	540.0	540.0	540.1	539.7	539.9	540.0
10	540.2	540.3	540.2	540.8	541.3	541.5	541.3	541.3	541.4	541.6	541.5	541.4	541.1
11	541.4	540.9	540.7	540.8	541.0	540.9	540.5	540.2	540.1	539.9	539.5	538.8	540.4
12	538.2	537.3	536.4	535.7	535.1	534.0	532.5	531.2	530.2	529.1	529.0	528.2	533.1
13	527.8	526.6	525.9	525.0	525.5	524.6	523.7	522.8	522.1	522.2	523.0	523.4	524.5
14	523.0	523.4	523.2	523.0	522.2	522.6	522.2	521.8	521.2	520.6	520.0	519.3	521.9
15	518.1	517.8	518.4	518.7	518.9	518.9	518.6	518.6	518.7	518.1	517.6	517.1	518.3
16	516.8	516.8	516.7	516.7	517.2	517.3	517.1	516.9	517.0	517.3	517.1	516.8	517.0
17	516.0	515.4	515.1	515.0	515.6	516.1	516.7	517.2	517.6	518.0	518.7	519.2	516.7
18	519.3	519.7	520.2	520.9	521.7	522.1	522.3	522.7	523.4	524.0	524.6	525.0	522.2
19	525.1	525.6	526.0	526.6	527.3	527.5	527.4	527.6	527.8	528.0	527.9	527.4	527.0
20	526.9	526.4	526.2	526.0	525.9	525.1	524.3	524.0	523.5	522.9	522.3	521.6	524.6
21	520.6	520.1	518.8	518.3	517.3	517.0	516.8	516.1	515.9	515.8	515.6	515.7	~~517.3~~
22	515.9	516.2	517.0	518.1	519.2	519.7	520.2	520.8	521.5	522.1	522.7	523.0	~~519.7~~
23	523.3	523.7	524.0	524.7	525.5	526.1	526.5	526.9	527.7	528.1	528.3	528.0	526.1
24	527.4	526.9	525.9	525.5	525.6	525.1	524.5	524.1	523.5	523.0	523.1	522.2	524.7
25	521.9	521.7	521.7	522.4	522.8	522.7	522.5	522.5	522.5	522.6	522.2	521.6	522.3
26	521.1	520.6	520.3	520.2	520.2	520.0	519.8	520.1	520.5	520.8	520.9	520.8	520.4
27	520.8	520.9	520.9	521.2	521.7	521.9	521.9	522.3	522.5	522.9	523.1	523.4	522.0
28	523.5	523.9	524.1	524.6	525.0	525.1	525.1	525.2	525.4	525.5	525.5	525.5	524.9
29	525.6	525.5	525.5	525.9	526.5	526.4	526.2	526.1	525.9	526.0	526.2	526.2	526.0
30	526.0	525.8	525.5	525.5	525.6	525.3	525.1	525.2	525.4	525.4	525.3	525.0	525.4

Table 2

NEUTRON INTENSITY MONITOR DATA. CORRECTED FOR AIR PRESSURE VARIATIONS.

INSTITUTION MAX PLANCK INSTITUT FUER PHYSIK UND ASTROPHYSIK, GERMANY
STATION ZUGSPITZE ALTITUDE 2950 METER
GEOGRAPHIC LATITUDE 47.42 DGR. LONGITUDE 10.98 DGR.
GEOMAGNETIC LATITUDE 47.90 DGR. LONGITUDE 93.75 DGR.
BIHOURLY SUM OF THE A AND B SECTION. SCALING FACTOR 100
MEAN STATION PRESSURE 530 TORR. BAROMETER COEFFICIENT -1.05 PERC./TORR

NOVEMBER 1977 UT END OF INTERVAL

Col 66

DAY	2	4	6	8	10	12	14	16	18	20	22	24	MEAN
1	5111	5106	5108	5133	5141	5147	5152	5134	5122	5114	5118	5123	5126
2	5123	5121	5127	5130	5153	5162	5114	5118	5088	5065	5035	5058	5109
3	5062	5049	5055	5110	5036	5159	5147	5156	5117	5117	5102	5108	5106
4	5098	5111	5122	5165	5169	5179	5163	5183	5178	5169	5181	5165	5157
5	5176	5181	5205	5243	5242	5233	5240	5234	5214	5207	5175	5193	5212
6	5209	5214	5226	5222	5228	5222	5252	5210	5199	5172	5185	5172	5209
7	5199	5219	5236	5280	5254	5276	5268	5264	5233	5229	5219	5230	5242
8	5219	5251	5265	5267	5256	5267	5267	5245	5242	5248	5203	5222	5247
9	5231	5220	5264	5238	5256	5295	5241	5250	5248	5235	5192	5183	5238
10	5207	5215	5220	5259	E5298	E5293	E5290	E5289	5283	5230	5241	5242	5255
11	5235	5197	5202	5232	5238	5247	5245	5222	5211	5204	5189	5183	5217
12	5157	5203	5227	5247	5255	5261	5208	5188	5196	5180	5171	5162	5204
13	5186	5166	5162	5175	5200	5225	5273	5259	5248	5229	5174	5180	5206
14	5151	5156	5138	5160	5215	5196	5219	5207	5166	5162	5118	5096	5155
15	5077	5100	5098	5113	5133	5171	5178	5177	5166	5153	5130	5131	5135
16	5138	5173	5137	5146	5176	5203	5207	5159	5157	5163	5172	5175	5158
17	5190	5184	5208	5179	5183	5190	5179	5175	5151	5137	5171	5163	5175
18	5145	5151	5153	5172	5190	5162	5176	5172	5180	5176	5164	5161	5167
19	5147	5156	5164	5161	5187	5179	5159	5159	5146	5158	5162	5158	5152
20	5145	5128	5139	5139	5147	5148	5137	5171	5158	5163	5157	5125	5147
21	5118.	5133.	5120.	5153.	5157.	5174.	5155.	5125.	5131.	5146.	5157.	5155.	~~5145.~~
22	5153.	5146.	5135.	5159.	5153.	5220.	5151.	5140.	5130.	5138.	5125.	5114.	~~[illegible]~~
23	5112	5098	5124	5119	5121	5122	5118	5103	5104	5098	5108	5124	5113
24	5096	5111	5097	5116	5122	5121	5140	5166	5137	5129	5156	5129	5127
25	5121	5135	5144	5152	5134	5137	5143	5097	5136	5205	5231	5233	5155
26	5199	5194	5206	5219	5239	5249	5208	5185	5129	5132	5157	5132	5138
27	5128	5116	5093	5117	5125	5122	5110	5100	5084	5053	5059	5050	5096
28	5047	5055	5076	5067	5096	5099	5108	5095	5071	5070	5053	5077	5075
29	5060	5089	5092	5098	5117	5115	5115	5114	5115	5096	5106	5081	5100
30	5075	5055	5055	5094	5110	5134	5131	5086	5075	5061	5076	5059	5084

Corrected/uncorrected Data: If pressure listed is higher than the standard pressure the uncorrected count rate is lower than it would be at standard pressure. This is because fewer particles are let in when there is a high pressure. Therefore, the counting rate has to be corrected for pressure in order to have an accurate count. The same idea occurs when the listed pressure is too low, but this time too many particles have been let in and the corrected count appears lower than the uncorrected.

Table 3

07/27/88

HEADER

ZUGSPITZE LATITUDE 47.42 LONGITUDE 10.98 ALTITUDE 2960 M
ZUGSPITZE INSTRUMENT IGY NEUTRON MONITOR
ZUGSPITZE STANDARD PRESSURE 530. MMHG COEFFICIENT -1.05 % / MMHG
ZUGSPITZE PRE-INCREASE BASELINE TIME INTERVAL 771122 080000-100000 UT
ZUGSPITZE PRE-INCREASE AVERAGE COUNTING RATE COUNTS PER SECOND
ZUGSPITZE TIME INTERVALS 7200
ZUGSPITZE SCALE FACTORS 100.

STATION	YYMMDD	SEC	TIME (UT) INTERVAL	CODE TD	UNCORR. COUNTS	PRESS. (MMHG)	CORR. COUNTS	% INC.
ZUGSPITZE	771121	7200	000000-020000	00	5623.	520.6	5118.	
ZUGSPITZE	771121	7200	020000-040000	00	5668.	520.1	5133.	
ZUGSPITZE	771121	7200	040000-060000	00	5721.	518.8	5120.	
ZUGSPITZE	771121	7200	060000-080000	00	5788.	518.3	5153.	
ZUGSPITZE	771121	7200	080000-100000	00	5856.	517.3	5167.	
ZUGSPITZE	771121	7200	100000-120000	00	58[illegible]9.	517.0	5174.	
ZUGSPITZE	771121	7200	120000-140000	00	5871.	516.8	5156.	
ZUGSPITZE	771121	7200	140000-160000	00	5874.	516.1	5125.	
ZUGSPITZE	771121	7200	160000-180000	00	5891.	515.9	5131.	
ZUGSPITZE	771121	7200	180000-200000	00	5915.	515.8	5146.	
ZUGSPITZE	771121	7200	200000-220000	00	5935.	515.6	5157.	
ZUGSPITZE	771121	7200	220000-240000	00	5930.	515.7	5155.	
ZUGSPITZE	771122	7200	000000-020000	00	5916.	515.9	5153.	
ZUGSPITZE	771122	7200	020000-040000	00	5890.	516.2	5146.	
ZUGSPITZE	771122	7200	040000-060000	00	5836.	517.0	5135.	
ZUGSPITZE	771122	7200	060000-080000	00	5802.	518.1	5159.	
ZUGSPITZE	771122	7200	080000-100000	00	5738.	519.2	5153.	
ZUGSPITZE	771122	7200	100000-120000	00	5783.	519.7	5220.	
ZUGSPITZE	771122	7200	120000-140000	00	5680.	520.2	5151.	
ZUGSPITZE	771122	7200	140000-160000	00	5639.	520.8	5140.	
ZUGSPITZE	771122	7200	160000-180000	00	5586.	521.5	5130.	
ZUGSPITZE	771122	7200	180000-200000	00	5563.	522.1	5138.	
ZUGSPITZE	771122	7200	200000-220000	00	5521.	522.7	5125.	
ZUGSPITZE	771122	7200	220000-240000	00	5490.	523.0	5114.	

*
****

E30ZUGS 07/27/88

THE YEAR, MONTH, & DAY

THE CODE "00" MEANS THAT ALL DATA HAS BEEN ENTERED

This is an E-file. It is the laser print out of what I entered into the computer. A header has been merged to label the information. The uncorrected, corrected, and pressures are shown.

Table 4

07/27/88

ZUGSPITZE LATITUDE 47.42 LONGITUDE 10.98 ALTITUDE 2960 M
ZUGSPITZE INSTRUMENT IGY NEUTRON MONITOR
ZUGSPITZE STANDARD PRESSURE 530. MMHG COEFFICIENT -1.05 % / MMHG
ZUGSPITZE PRE-INCREASE BASELINE TIME INTERVAL 771122 080000-100000 UT
ZUGSPITZE PRE-INCREASE AVERAGE COUNTING RATE 71.57 COUNTS PER SECOND
ZUGSPITZE TIME INTERVALS 7200
ZUGSPITZE SCALE FACTORS 100.

STATION	YYMMDD	SEC	TIME (UT) INTERVAL	CODE TD	UNCORR. C/S	PRESS. (MMHG)	CORR. C/S	% INC.
ZUGSPITZE	771121	7200	000000-020000	00	78.10	520.6	71.08	-.7
ZUGSPITZE	771121	7200	020000-040000	00	78.72	520.1	71.29	-.4
ZUGSPITZE	771121	7200	040000-060000	00	79.46	518.8	71.11	-.6
ZUGSPITZE	771121	7200	060000-080000	00	80.39	518.3	71.57	.0
ZUGSPITZE	771121	7200	080000-100000	00	81.33	517.3	71.76	.3
ZUGSPITZE	771121	7200	100000-120000	00	81.65	517.0	71.86	.4
ZUGSPITZE	771121	7200	120000-140000	00	81.54	516.8	71.61	.1
ZUGSPITZE	771121	7200	140000-160000	00	81.58	516.1	71.18	-.5
ZUGSPITZE	771121	7200	160000-180000	00	81.82	515.9	71.26	-.4
ZUGSPITZE	771121	7200	180000-200000	00	82.15	515.8	71.47	-.1
ZUGSPITZE	771121	7200	200000-220000	00	82.43	515.6	71.63	.1
ZUGSPITZE	771121	7200	220000-240000	00	82.36	515.7	71.60	.0
ZUGSPITZE	771122	7200	000000-020000	00	82.17	515.9	71.57	.0
ZUGSPITZE	771122	7200	020000-040000	00	81.81	516.2	71.47	-.1
ZUGSPITZE	771122	7200	040000-060000	00	81.06	517.0	71.32	-.3
ZUGSPITZE	771122	7200	060000-080000	00	80.58	518.1	71.65	.1
ZUGSPITZE	771122	7200	080000-100000	00	79.69	519.2	71.57	.0
ZUGSPITZE	771122	7200	100000-120000	00	80.32	519.7	72.50	1.3
ZUGSPITZE	771122	7200	120000-140000	00	78.89	520.2	71.54	.0
ZUGSPITZE	771122	7200	140000-160000	00	78.32	520.8	71.39	-.3
ZUGSPITZE	771122	7200	160000-180000	00	77.58	521.5	71.25	-.4
ZUGSPITZE	771122	7200	180000-200000	00	77.26	522.1	71.36	-.3
ZUGSPITZE	771122	7200	200000-220000	00	76.68	522.7	71.18	-.5
ZUGSPITZE	771122	7200	220000-240000	00	76.25	523.0	71.03	-.8

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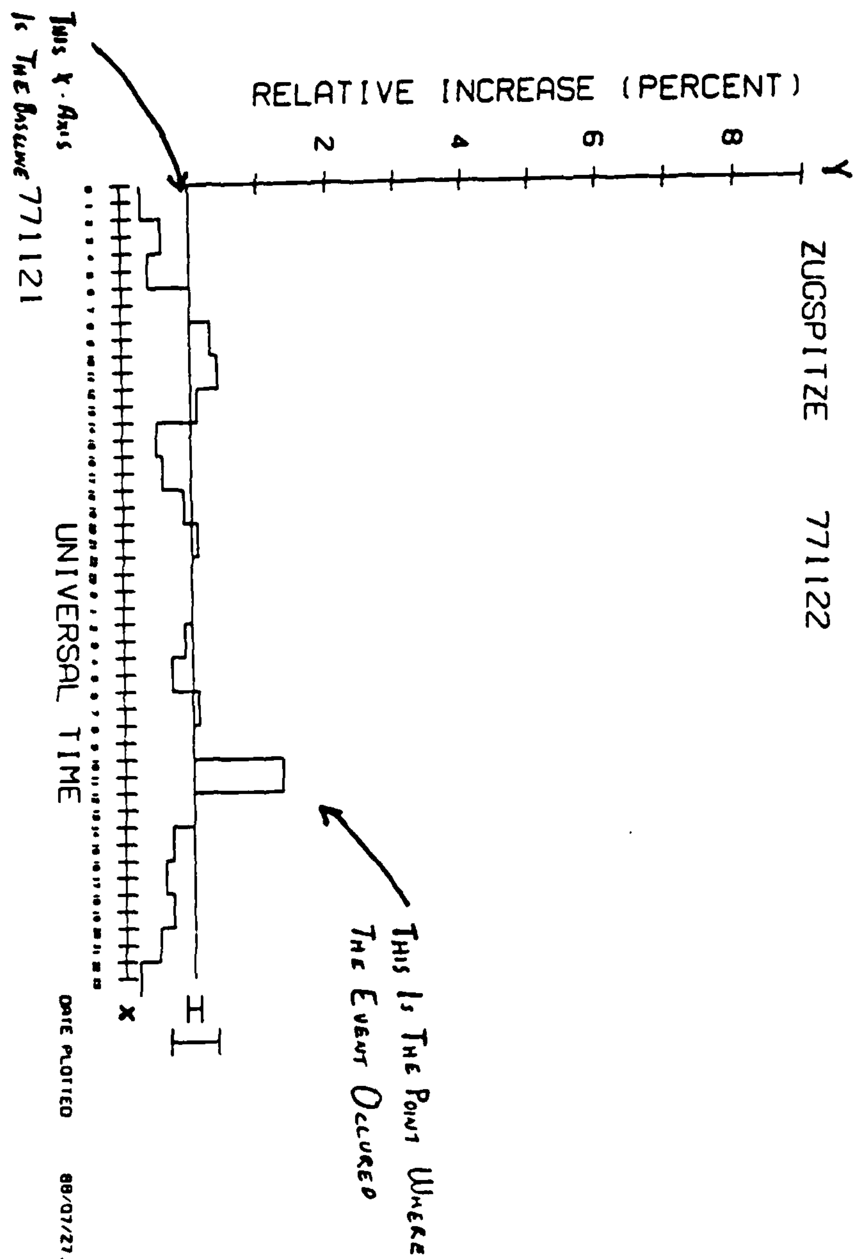
C30ZUGS 07/27/88

THIS IS THE BASEL
THAT ALL OF THE
OTHER COUNTS HAV
BEEN COMPARED T

This is a C-file. The corrected and uncorrected counts have been changed to standard form in counts per second. The percents of increase have also been calculated. The corrected counts are being compared to the baseline (labeled as zero in the percent of increase column) that is an interval before the event occured. The comparison shown in the percent of increase allows you to see where the event occurs (when there are a greater amount of particles).

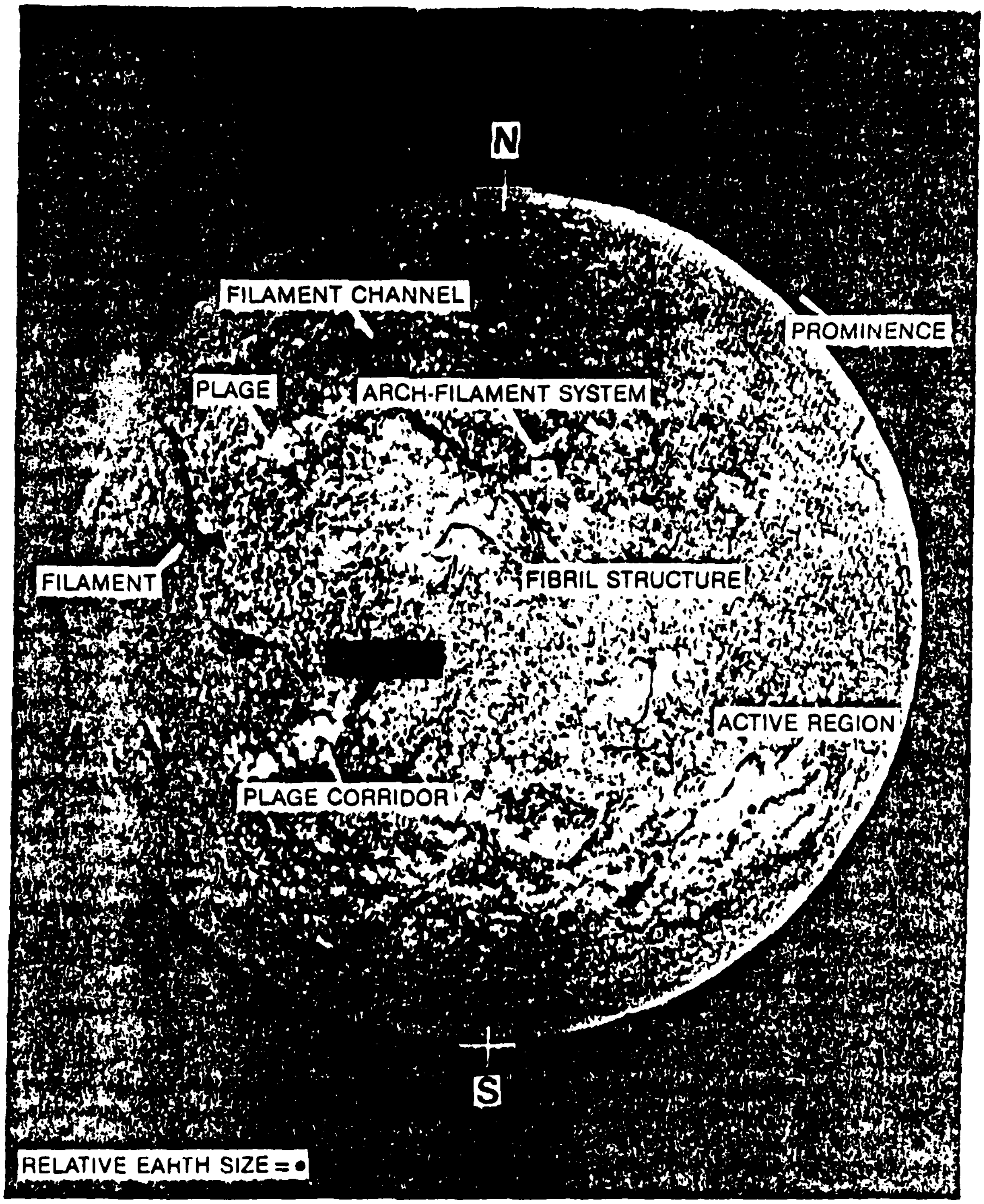
Table 5



This is the plotted data. It is obvious where the event occured because of the rise in the y-axis. This plot is the result of the C-file.

Table 6

THIS DIAGRAM OF THE SUN SHOWS A PICTURE OF A SUNSPOT



The Sun
taken in hydrogen alpha light
photographed through a solar telescope
on 23 June 1979, 1536 UT,
at Boulder, Colorado

Table 7

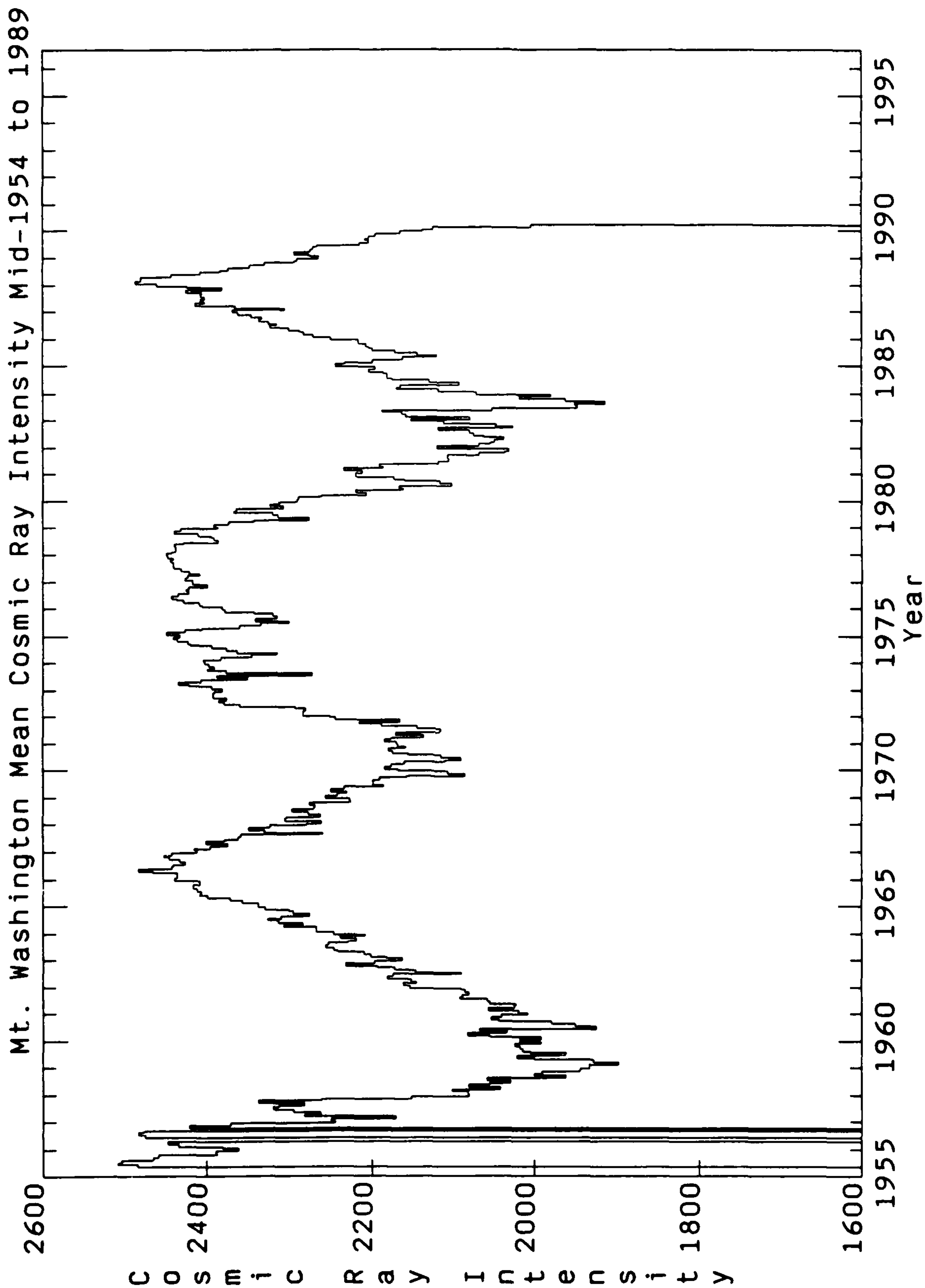

Mt. Washington Mean Cosmic Ray Intensity Mid-1954 to 1989
Cosmic Ray Intensity
2600
2400
2200
2000
1800
1600
Year
1955
1960
1965
1970
1975
1980
1985
1990
1995

Table 8

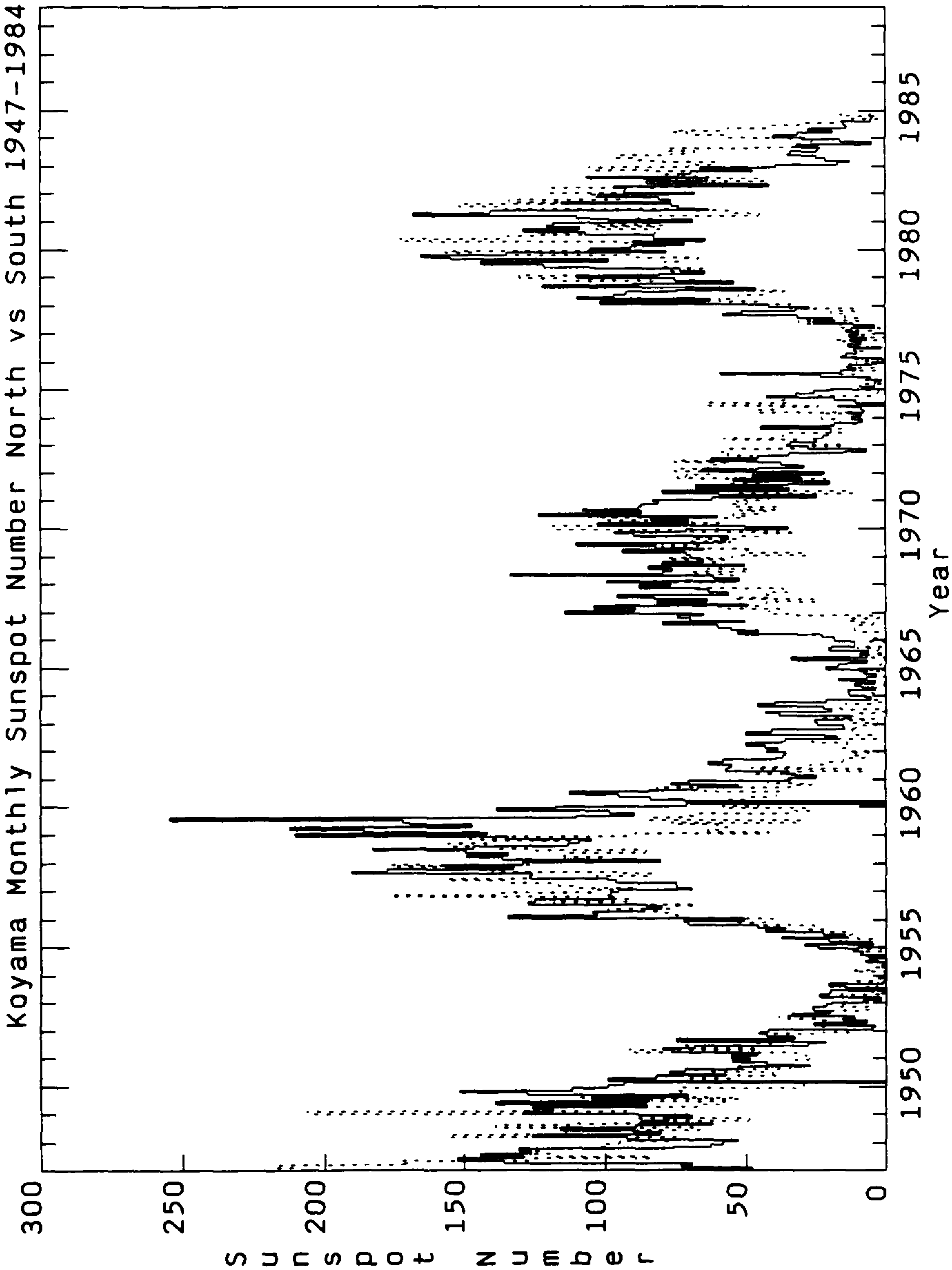

Koyama Monthly Sunspot Number North vs South 1947-1984
Year
1950
1955
1960
1965
1970
1975
1980
1985
Sunspot Number
0
50
100
150
200
250
300

Table 9

David Kelleher

August 9, 1989

Air Force Geophysics Laboratory
Hanscom Air Force Base
Bedford, Massachusetts

Assembly of a Radio Wave Scintillations Amplifier

Mentor:

Howard Kuenzler

Acknowledgements:

I would like to thank everyone at the Geophysics Lab who helped me during this learning experience. I would especially like to thank my mentor, Howard Kuenzler, and others who explained the radio wave scintillations research project to me.

Summary of Activities:

Due to the effects of the ionosphere, communication with a satellite can be lost for periods of time. Research is being done to learn more about the ionosphere so those periods can be predicted ahead of time. Currently, there are plans to computerize eight stations which receive a radio wave signal from a satellite after it is affected by the ionosphere. An amplifier will be included in each of the stations. At the Geophysics Lab, I helped assemble the amplifier systems while I learned about the other aspects of the project.

Detailed Description of Activities:

The ionosphere, which is a layer of ionized gasses high in the atmosphere, bends low frequency radio waves which pass through it. However, even high frequency radio waves are affected by small areas of high and low density in the ionosphere. Those spots change the frequency and direction of radio waves travelling through the earth's atmosphere. As a result, more than one radio wave coming from a satellite can reach an antenna. Since the radio waves are out of phase, they either combine, strengthening the signal, or negate each other, weakening the signal. It is possible that the signal can be weakened to the point where it becomes to faint to be detected. During those times, communications is not possible.

Scintillations of radio waves are the fluctuations of the strength of a signal passed through the ionosphere. The Air Force wants to know more about scintillations and what happens to radio waves passing through the ionosphere during different atmospheric conditions. That information would help determine what affects the ionosphere. Also, periods where no communication is possible could be predicted ahead of time.

Currently, a satellite is transmitting radio waves to eight receiving stations in locations such as Greenland and Peru. The information about the strength of the satellite signal is graphed onto chart paper by a machine. Calculations about the scintillations must be done by hand. In the future, the process will be computerized. The upgraded receiving stations will first amplify the signal. Next, the signal will be digitized, or converted into numbers, fifty times a second by an analog to digital converter. A computer will then perform calculations on the digitized data. The calculations include the average strength of the signal, how much the signal fades (deviation from the average signal strength), and how often the signal is lost. The resulting statistics and information about the radio waves will be stored in memory.

I was involved with the assembly of the amplifier systems. Before the information about the satellite signal is sent to the computer, the amplifier strengthens and filters the signal received by the antenna. A total of eight amplifier systems are needed. Each system consists of one regulator circuit board and eight amplifier circuit boards, which are inserted into a rack. During my apprenticeship, I assembled most of the components on the eight regulator boards and seventy amplifier boards. I also assembled the system racks and began wiring them.

First, I received the box of parts, sorted the components, and identified them on a parts list (see figures 1 and 2). Most of the components I sorted were resistors, capacitors, transistors, and integrated circuit chips. Some of the resistors were labelled with a color code, which I learned how to use.

Since integrated circuits are vulnerable to static electricity, I worked in an Electrostatic Discharge (ESD) protected area. This consisted of an electrically grounded floor mat, table mat, and wristband. The station also included a 1% stainless steel shirt. The ESD protected area was important because static electricity can damage ICs.

To learn more about ICs, I used a breadboard, called Protoboard. It is used to wire and test circuit designs. Using the breadboard, I practiced wiring logic gates, counters, lights, and switches together.

I also learned about the process of making a printed circuit board. My mentor showed me the prototype for the regulator board and the original drawings for the circuit boards. He also explained the procedure used to develop and manufacture a board.

After learning soldering techniques, I assembled the first amplifier board and the first regulator board. Schematics of the circuit boards helped; each component was listed on the diagrams (see figures 3 and 4). For example, the first resistor was labelled R1 and the third capacitor was labelled C3. Those names were also printed on the circuit boards, which made it easy to determine where each component should go. After I finished assembling the first regulator board and the first amplifier board, they were tested.

While they were being tested, I assembled the amplifier system racks and began wiring the backs of the connectors. Each rack holds a regulator board and eight amplifier boards (see figure 5). First, I adjusted the racks so the connectors we had would fit inside. Then, I attached the connectors onto the back of the racks. To locate where each connector should go, I put a regulator board and an amplifier board onto card mounts. The mounts slid into the rack, and the attached circuit boards plugged into the connectors.

After the racks were assembled, I wired the backs of the connectors for some of the racks. Certain pins on each connector were wired together according to a drawing (see figure 6). This involved cutting long wires and small pieces of insulation. The wire was soldered onto a pin on each of the connectors, and insulation was placed on the wire between the solder connections.

A total of eight systems were needed. Each consisted of a rack, which I assembled and wired, a regulator board, and eight amplifier boards. Totally, there were eight regulator boards and seventy amplifier boards to be assembled. After the first amplifier and regulator boards were tested, I spent much of my apprenticeship assembling the remainder of the boards.

Also, I read sections of books dealing with relevant topics. J. Ratcliff's book, the Introduction to the Ionosphere and Magnetosphere, explained the ionosphere and some of its characteristics. The TI Integrated Circuits Catalog for Design Engineers contained information about many integrated circuits. Also, I read about aurorae in Robert Eather's Majestic Lights. Aurorae is caused when solar particles interact with the ionosphere.

Conclusion:

In conclusion, I would like to thank everyone who helped me during my apprenticeship. I have learned much about the ionosphere and its effects. Due to the effort of my mentor and others, I was able to understand the amplifier system's role in the satellite receiving stations. Also, I gained valuable engineering experience which will help me in college and beyond.

NO.	NOMENCLATURE	MFGR	PART#	SUPPLIER	STOCK#	PRICE	QNT.	COST
	CARDMOUNT RACK 1 per system							
1	Cardrack	Vector	CCM14A	Newark	38F1110	$94.88	1	$94.88
2	Module 1"	Vector	CM45A65-1	Newark	38F1111	$9.26	8	$74.08
3	Module 2"	Vector	CM45A65-2	Newark	38F1112	$9.61	2	$19.22
4	Module 4"	Vector	CM45A65-4	Newark	38F1114	$10.87	1	$10.87
5	Card Edge Connector	Cinch	50-44A-30	Newark	29F963	$3.43	9	$30.87
6	Amplif. output connector	Cinch	DC-37S	Newark	43F209	$11.45	1	$11.45
7	Amplif. cabl. plug IDC	Cinch	FC-37PT	Newark	44F6369	$10.04	1	$10.04
8	A/D input cabl. plug IDC	Cinch	FC-37ST	Newark	44F6370	$11.42	1	$11.42
9	Screwlock, female	Cinch	D20418-2	Newark	43F230	$0.82	4	$3.28
10	Screwlock, male	Cinch	D20419-0	Newark	43F231	$0.45	4	$1.80
11	Recorder out connector	Cinch	DB-25S	Newark	43F206	$5.25	1	$5.25
12	Recorder cabl. plug IDC	Cinch	FC-25PT	Newark	44F6367	$6.99	1	$6.99
13	BNC (input,output,test)	SPC	SPC-1094U-LN-G	Newark	46N7366	$1.63	25	$40.75
							Sum	$320.90
	AMPLIFIER CARD 8 per system							
14	U1 Op Amp	PMI	OP41GP	Gerber		$2.60	1	$2.60
15	U2 Op Amp	PMI	OP27EP	Gerber		$3.53	1	$3.53
16	U3 Op Amp	PMI	OP07EP	Gerber		$2.50	1	$2.50
17	U4 Op Amp	PMI	OP200GP	Gerber		$2.95	1	$2.95
18	U5 Op Amp	LINEAR	LTC1062CN8	Gerber		$4.40	1	$4.40
19	U6 Op Amp	PMI	OP200GP	Gerber		$2.95	1	$2.95
20	C1 0.1 uf 10% .2"	AVX	SR215C104KAA	Active	31038	$0.16	1	$0.16
21	C2 100 pf 10% .2"	AVX	SR211A101JAA	Active	31104	$0.21	1	$0.21
22	C3 0.1uf 10% .2"	AVX	SR215C104KAA	Active	31038	$0.16	1	$0.16
23	C4 0.1 u 10% .2"	AVX	SR215C104KAA	Active	31038	$0.16	1	$0.16
24	C5 1.0 uf 20% .2"	AVX	SR305E105MAA	Active	31073	$0.52	1	$0.52
25	C6 0.1 u 10% .2"	AVX	SR215C104KAA	Active	31038	$0.16	1	$0.16
26	C7 0.1 uf 10% .2"	AVX	SR215C104KAA	Active	31038	$0.16	1	$0.16
27	R1 1.0M	Corning	RN55D1004F	Active	73029	$0.08	1	$0.08
28	R2 2.0K	Corning	RN55D2001F	Active	73021	$0.08	1	$0.08
29	R3 1.0M	Corning	RN55D1004F	Active	73029	$0.08	1	$0.08
30	R4 1.0M	Corning	RN55D1004F	Active	73029	$0.08	1	$0.08
31	R5 332K	Corning	SMA4-332K-1	Active	73099	$0.06	1	$0.06
32	R6 1.0K	Corning	RN55D1001F	Active	73020	$0.08	1	$0.08
33	R7 1.0K	Corning	RN55D1001F	Active	73020	$0.08	1	$0.08
34	R8 13.0K	Corning	RN55D1302F	Active	73136	$0.08	1	$0.08
35	R9 13.0K	Corning	RN55D1302F	Active	73136	$0.08	1	$0.08
36	R10 10.2K	Corning	RN55D1022F	Active	73025	$0.08	1	$0.08
37	R11 13.0K	Corning	RN55D1302F	Active	73136	$0.08	1	$0.08
38	R12 13.0K	Corning	RN55D1302F	Active	73136	$0.08	1	$0.08
39	R13 4.99K	Corning	RN55D4991F	Active	73022	$0.08	1	$0.08
40	R14 1.0K	Corning	RN55D1001F	Active	73020	$0.08	1	$0.08
41	R15 10K	Bourns	3252L-1-103-M	Gerber	(Panel Mnt.)	$15.86	1	$15.86
42	V1 Varistor	GE	V22MA1B	Newark		$1.55	1	$1.55
							SUM	$38.97

Figure 1. Parts list for the system racks and amplifier boards.

NO.	NOMENCLATURE	MFGR	PART#	SUPPLIER	STOCK#	PRICE	QNT.	COST
	REGULATOR & MONITOR 1 per system							
43	Power Supply	Acopian	DB15-30	Acopian		$115.00	1	$115.00
44	AC Plug & Fuse	Corcom	6VJ4	Active	79100	$15.75	1	$15.75
45	AC Switch	C&K	DM62J12S205Q	Newark	87F573	$4.25	1	$4.25
46	Digital Panel Meter	Modutek	BL130202	Brownell		$55.00	1	$55.00
47	Meter Connectors	CA	CA-S131DS2-F	Com-Sale		$2.22	2	$4.44
48	Thumbwheel Switch	C&K	301119000	Gerber		$4.01	1	$4.01
49	Screws	C&K	4127-01	Gerber		$0.21	2	$0.42
50	End Plates	C&K	4004	Gerber		$0.80	2	$1.60
51	Nuts	C&K	4035	Gerber		$0.03	4	$0.12
52	Switch Connector	C&K	4046	Gerber		$3.66	1	$3.66
53	PC Board Connector	CA	CA-S111DS2-F	Com-Sale		$1.48	1	$1.48
54	U20 Regulator +5v. TO220	Fairchild	uA7805UC	Active	09220	$0.52	1	$0.52
55	U21 Regulator -5v. TO220	Fairchild	uA7905UC	Active	09370	$0.65	1	$0.65
56	U22 Reference -10 Volts	Linear	LT1031DCH	Gerber		$3.95	1	$3.95
57	U23 Op Amp	PMI	OP07EP	Gerber		$2.50	1	$2.50
58	U24 Clock	Statek	PXO-1000	1st Freq		$12.10	1	$12.10
59	U25 Clock	Statek	PXO-1000	1st Freq		$12.10	1	$12.10
60	T20 Transistor	Motorola	2N3906A	Active	02212	$0.21	1	$0.21
61	T21 Transistor	Motorola	2N3906A	Active	02212	$0.21	1	$0.21
62	Heat Sink	Aavid	50738	Active	77068	$0.15	1	$0.15
63	R20 2.21K	Corning	RN55D2211F	Active	73148	$0.10	1	$0.10
64	R21 10.2K	Corning	RN55D1022F	Active	73025	$0.10	1	$0.10
65	R22 10.2K	Corning	RN55D1022F	Active	73025	$0.10	1	$0.10
66	R23 10.2K	Corning	RN55D1022F	Active	73025	$0.10	1	$0.10
67	R24 1.00K	Corning	RN55D1001F	Active	73020	$0.10	1	$0.10
68	R25 1.00K	Corning	RN55D1001F	Active	73020	$0.10	1	$0.10
69	R26 90.9K	Corning	SMA4-90.9K-1	Active	73119	$0.60	1	$0.60
70	R27 10.2K	Corning	RN55D1022F	Active	73025	$0.10	1	$0.10
71	R28 10.2K	Corning	RN55D1022F	Active	73025	$0.10	1	$0.10
72	R29 10.2K	Corning	RN55D1022F	Active	73025	$0.10	1	$0.10
73	R30 10.2K	Corning	RN55D1022F	Active	73025	$0.10	1	$0.10
74	C20 1.0 uf 20% .2"	AVX	SR305E105MAA	Active	31073	$0.52	1	$0.52
75	C21 0.1 uf 10% .2"	AVX	SR215C104KAA	Active	31038	$0.16	1	$0.16
76	C22 3.3 uf .1"	Sprague	199D335X0035BA1	Newark	17F2053	$0.33	1	$0.33
77	C23 1.0 uf 20% .2"	AVX	SR305E105MAA	Active	31073	$0.52	1	$0.52
78	C24 10 uf .1"	Sprague	199D106X0016CA1	Newark	17F2032	$0.32	1	$0.32
79	C25 10 uf .1"	Sprague	199D106X0016CA1	Newark	17F2032	$0.32	1	$0.32
80	LED Red	Dialco	558-0101-003	Gerber		$1.03	1	$1.03
81	LED Yellow	Dialco	558-0301-003	Gerber		$1.35	1	$1.35
82	Strip Header	AP	929834-01-36	Active	40064	$1.36	1	$1.36
83	Jumpers	AP	40092A-Gold	Active	70197	$0.15	4	$0.60
84	Standoff,1/4" Al, #6	Keystone	3464	Newark	89F2607	$0.06	4	$0.24
								Sum $246.47

Figure 2. Parts list for the regulator boards.

4/14/89 6.16 AM

Figure 3. Amplifier circuit board schematic.

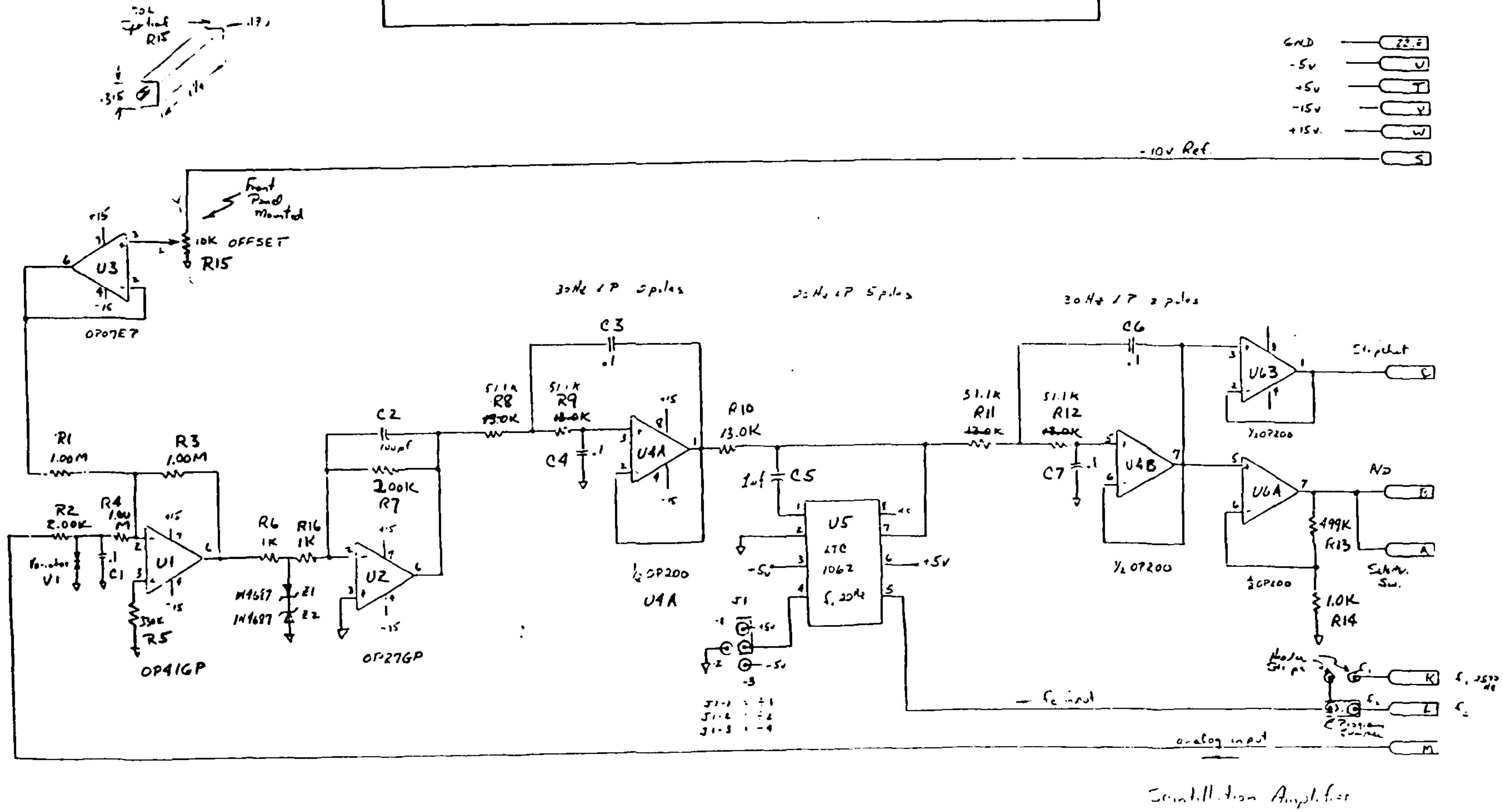
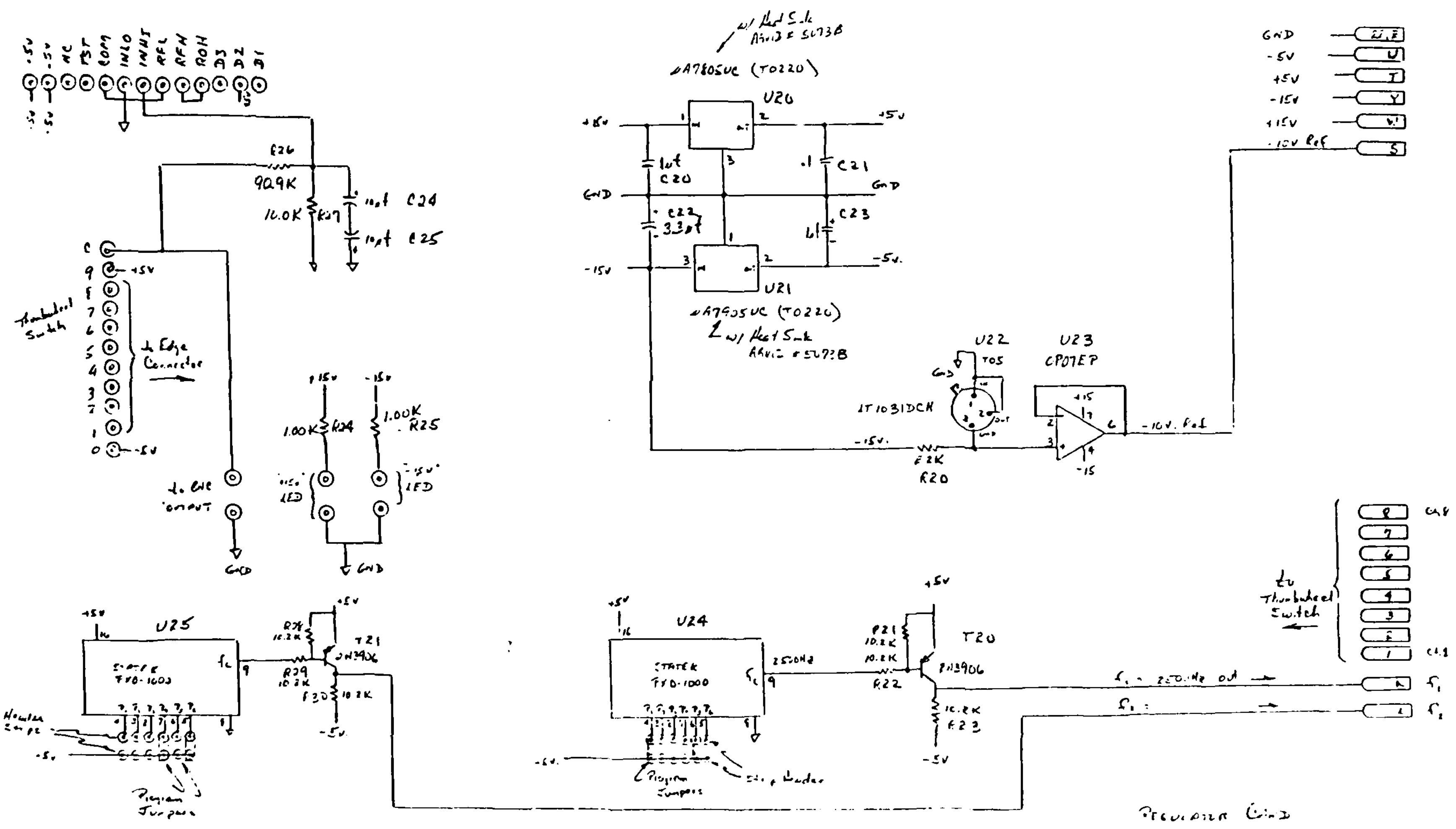


Figure 4. Regulator circuit board schematic.



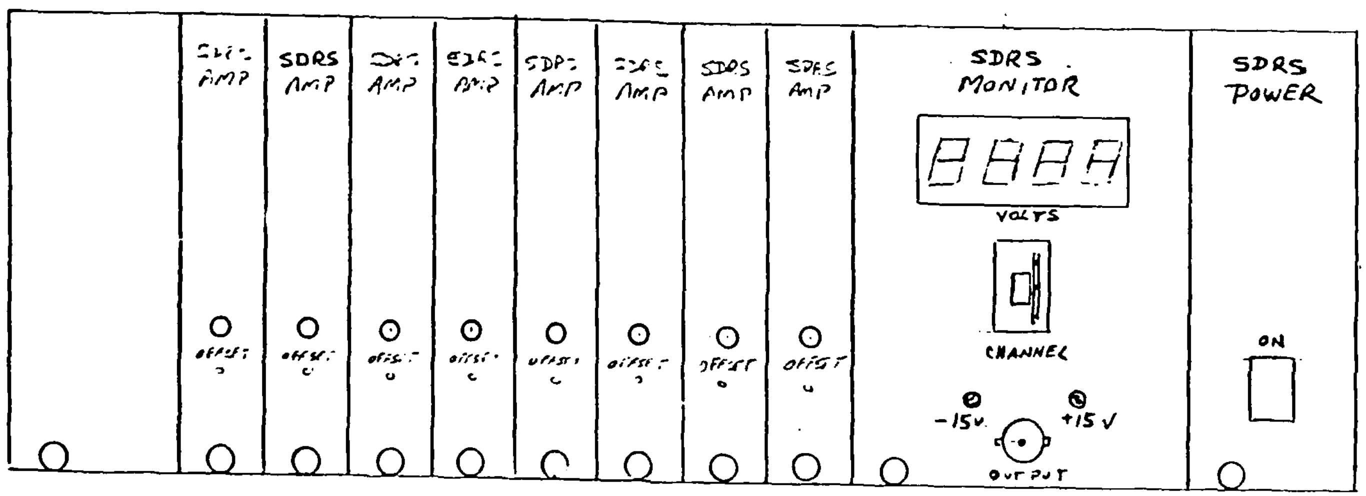


Figure 5. System rack panels.

½ Scale

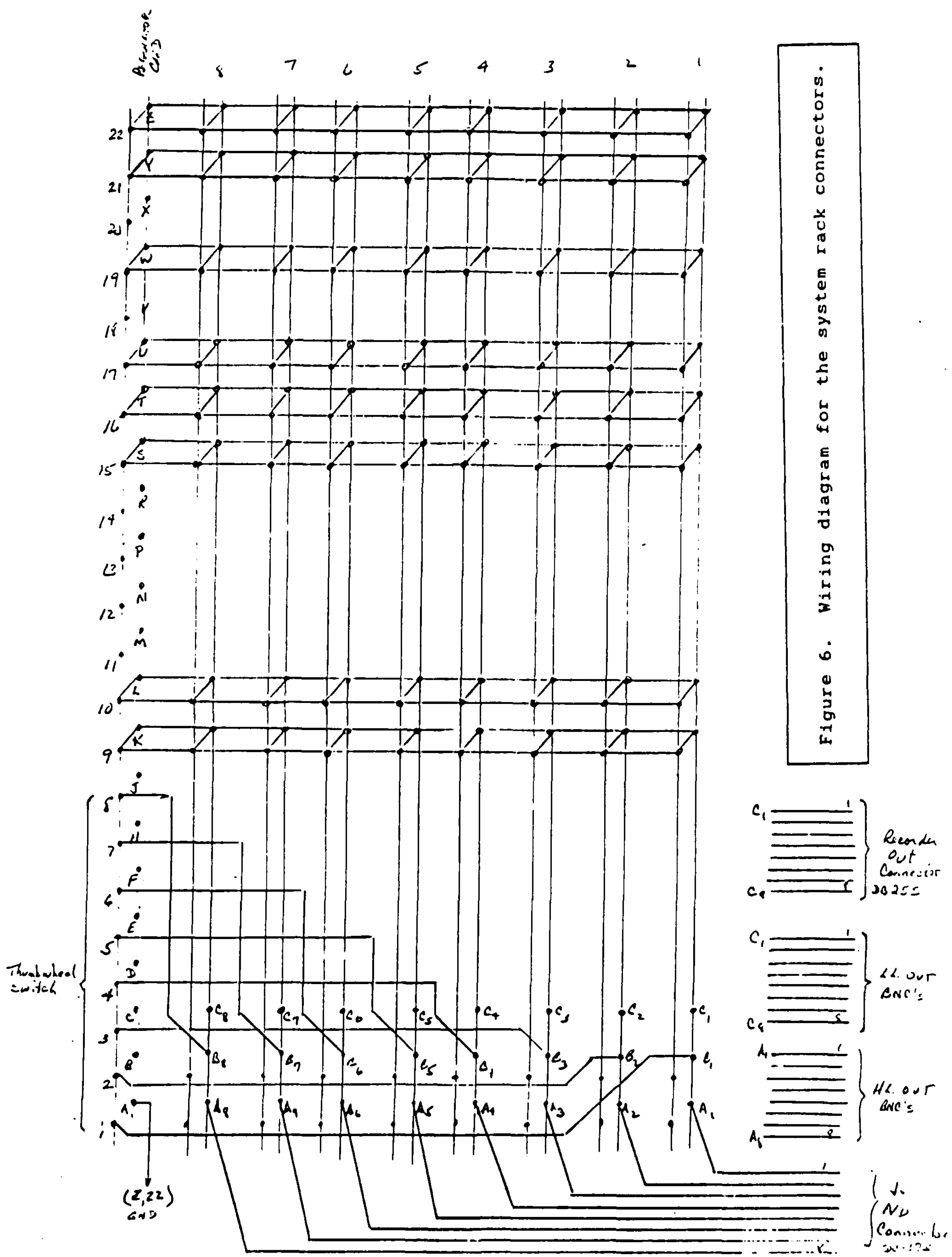


Figure 6. Wiring diagram for the system rack connectors.

Displaying Tektronix Files on a Zenith PC
John Walker
with Dr. Frederick Rich
at the Geophysics Laboratory

I would like to thank, most of all, Dr. Rich for his continued guidance and support over the last two summers. He was always available when I needed him, yet never hung over me.

Dr. Rich taught me that one of the best ways to make oneself very popular is to be the resident expert in some subject. (Dr. Rich's field is computers.) Aside from the informal talks we had in which I learned more about computers than I ever will anywhere else, I also had the opportunity to try my hand at helping people with computer problems when Dr. Rich was out.

Thanks also to Dr. Howard Singer for the loan of his book on Space Physics. I was actually able to understand it, which was an immense morale lifter. Also to Dr. William Denig for his ever-present enthusiasm. He always had a friendly word for me. And, finally, thanks to Dave Kelleher, a fellow apprentice. He endured many a car-ride home listening to me babbling about my programming.

Since I worked for the same mentor in the same lab last summer, I was already familiar with the Geophysics Laboratory. I was able to get to work with minimal introduction.

My assignment for the summer was to write a program for the Zenith Z-248 that would display Tektronix files. Tektronix manufactures graphics display terminals commonly used for CAD/CAM, though in the GL they are more commonly used for data display. The language that these terminals use, appropriately called Tektronix, has become an industry standard. My mentor, Dr. Rich, required a program that could correctly interpret Tektronix files and accurately display them on the screen. Although he had two display programs already, neither was adequate - one operated on a mainframe and displayed only black and white, while another, incorporated into his communication software, was clumsy to use and displayed only eight colors. He required one that would display sixteen colors, taking full advantage of his computer's video display to more accurately display the Tektronix files.

Unfortunately, Tektronix files are not simply a sequence of X and Y coordinates. Because of the differing resolutions of their various machines, Tektronix computers encode the X-Y values in a special manner. Tektronix divides the addressable area of the screen into 1024 groups (a 32 x 32 grid), and defines one of those groups with a Hi-X and Hi-Y value. Each of those Hi- groups are further divided into 1024 Lo- groups, defined with a Lo-X and Lo-Y value. Each of the Lo- groups is further divided into 16 parts (a 4 x 4 grid), defined with an extra byte (EB) of information. (Figure 1 is a pictorial explanation of this.) The specific location is scaled from a 4096 x 4096 grid (the addressable size of a Tektronix terminal) to find the specific pixel to be illuminated. By encoding data in this format, Tektronix maintained compatibility between its older models and its newer models; the newer models, with higher resolution, utilize the extra byte, while the older ones, though still able to read files created by newer Tektronix terminals, do not.

Unfortunately, the values are not always included in the file. When one of the values is the same from one point to the next, Tektronix does not bother to rewrite it. For example, a horizontal line would be represented by two points: the first containing the full range of data (assuming it is the first point in a file), but the second would not include a Hi-X or Lo-X value, nor would the X portion of the EB be needed. So all the values must be retained from point to point - it is not possible to start with a "clean slate" at each point. There are some rules, however: the order of bytes must always be Hi-Y, EB, Lo-Y, Hi-X, Lo-X; and if there is an EB, it <u>must</u> be followed by a Lo-Y. Finally, every sequence of bytes must end with a Lo-X value. Therefore, we have the following possible combinations of bytes:

1	Hi-Y	EB	Lo-Y	Hi-X	Lo-X
2	Hi-Y		Lo-Y	Hi-X	Lo-X
3	Hi-Y	EB	Lo-Y		Lo-X
4	Hi-Y		Lo-Y		Lo-X
5	Hi-Y				Lo-X
6		EB	Lo-Y	Hi-X	Lo-X
7			Lo-Y	Hi-X	Lo-X
8		EB	Lo-Y		Lo-X
9			Lo-Y		Lo-X
10					Lo-X

Furthermore, although there is some overlap, each byte has a limited legal range of values (see Table 1) which I was able to take advantage of to define the specific byte type.

Once a point is read, it is necessary to read another one, and draw a connecting line between the two; this is continued until the end of the file is reached. However, some points are defined as "dark" - i.e. not drawn. These are used when it is desired to move the location of the "pen" without drawing a line. These are preceded by a <GS> command (1D in hexadecimal) in the file. (See Appendix A for a sample Tek file.)

In order for a computer to put together the data to form coherent X-Y coordinates, it must think numerically, rather than graphically. Each byte (Hi-Y, EB, etc.) is an eight digit binary number. The first two digits (bits 6 and 7) of each byte are identifier tags; they are not used to determine the coordinate values. (The tag bits correspond to the byte type: 01 for Hi-Y and Hi-X, 11 for the EB and Lo-Y, and 10 for Lo-X.) The fifth bit of the EB is not used. The five remaining bits (bits 1-5) of the Hi- bytes are combined with the five remaining bits from the Lo- bytes and the two bits from the EB to form a twelve bit binary number. (See figure 2) This number is in the range 0-4095. It is then scaled to the number of pixels that the PC's monitor has, and displayed.

The reason for a 4096 x 4096 grid is the following: Tektronix uses a virtual display area off the top of the screen (above 3120) to enable users to store objects in memory without actually displaying them.

I gained a lot of experience programming in BASIC for Dr. Rich last summer, so he set me up with Microsoft QuickBASIC on an IBM PC AT. Unfortunately, within a week the AT failed - a victim of recurrent power surges (it was on the same outlet as a thermal printer that was periodically used). So while waiting for the AT to be repaired, I used a PC portable, with

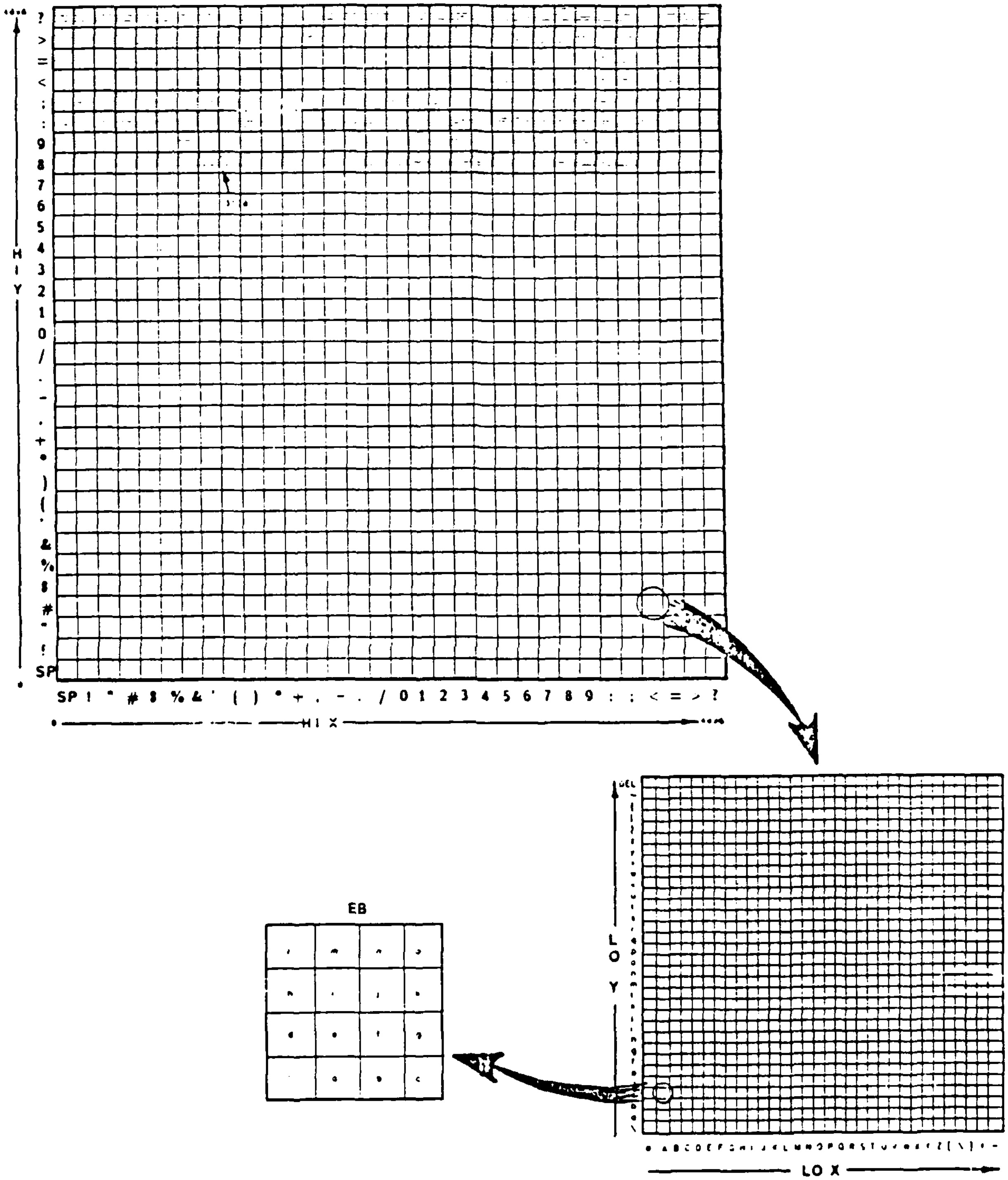
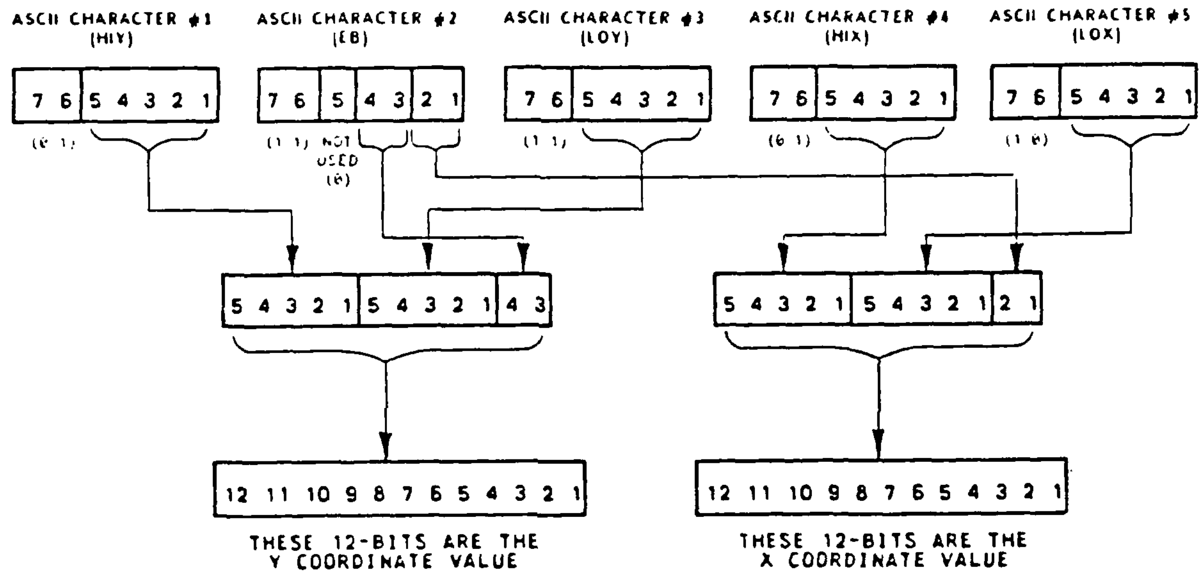


Figure 1

The legal value range for each coordinate character is:

Hi-Y and Hi-X	: "space" through "?"	($20 through $3F)
Lo-Y and EB	: "/" through "<DEL>"	($60 through $7F)
Lo-X	: "@" through "_"	($40 through $5F)

Table 1



- BITS 7 AND 6 OF EACH ASCII CHARACTER ARE "TAG" BITS, WHICH ARE USED BY THE PLOTTER TO IDENTIFY THE 5 ASCII CHARACTERS.
- BIT 5 OF THE SECOND ASCII CHARACTER (EB) IS NOT USED.

Conversion of Hi-Y, EB, Lo-Y, Hi-X and Lo-X to X and Y Coordinates

Figure 2

Apprendices can be obtained from

Universal Energy Systems, Inc.

OCCUPATIONAL AND ENVIRONMENT HEALTH LABORATORY

USING SOIL AND AQUATIC BIOASSAYS TO ASSESS THE TOXICITY OF CONTAMINATED SOIL AND WASTEWATER

JONATHAN J. JARRELL

August 1989

Final Report

MENTOR: LT COL BINOVI

AF Occupational and Environmental Health Laboratory
Environmental Quality Branch (ECQ)
Brooks Air Force Base
San Antonio, Texas 78235

i. Purpose

In recent years, the Air Force has seen a growing demand for both terrestrial and aquatic biomonitoring capabilities as a result of the EPA's implementation of biomonitoring as a federal requirement. The requirements for terrestrial biomonitoring, the use of living organisms to assess the toxicity of contaminated soil on agroecosystems, and aquatic biomonitoring, the use of living organisms to periodically assess the toxicity of wastewater, are met by performing several soil and aquatic bioassays. The purpose of this study is to show how these soil and aquatic bioassays are run and how they meet those requirements set by the EPA.

ii. Problem

The objective of these tests is to determine whether the given samples (either soil suspected of contamination or wastewater discharge) can successfully support life (either plants or animals).

This problem can be addressed by conducting laboratory bioassays. A bioassay is a test used in estimating the nature, constitution, or potency of a material based on the reaction that follows its application to living matter (Finney, 1978). The use of bioassays is a vital part to the Air Force's biomonitoring capabilities in that bioassays take a short period of time to conduct and they are accurate. The organisms commonly used in these bioassays are: in the soil bioassay, pinto beans and sorghum, representatives of the two major plant families (dicotyledons and monocotyledons); in the aquatic bioassay, four organisms are used depending on which type of test is used, either water fleas (*Daphnia magna*, *Daphnia pulex*, or *Ceriodaphnia dubia*), which are abundant in limnetic communities and are large enough to be easily distinguished from other zooplankton (Berner, 1986) or Fathead minnows (*Pimephales promelas*), a popular bait fish that is preyed upon by other fish and birds (Peltier & Weber, 1985). Further information on all these species is found in Appendix A.

iii. Scope

This report covers the course of several bioassays that were performed in July and August 1989. Among the tests were a soil bioassay which was conducted for 14 days, and a series of aquatic bioassays which varied from 24 to 96 hours each. Although these tests were quite extensive, they had a very limited scope. First, the tests themselves measured the acute toxicity only and not the chronic effects of the contaminated soil on the plants nor the wastewater's on the Daphnids/fish (eg. reproduction of water fleas, growth of Fathead minnows, etc.). Secondly, whereas plants and aquatic organisms were tested, the other major families in the animal kingdom, like mammals and birds were not considered. Finally, it must be reminded that these bioassays were, like many other scientific experiments, conducted in pure environments where phenomenon such as flooding, drought, runoff, or predators/consumers are not present.

iv. Procedures

Soil Bioassay

On 29 June 89, our laboratory received four soil samples from W— AFB that were to undergo a soil bioassay; the contaminant was a herbicide that had runoff into adjacent croplands. Two of the samples were contaminated with the herbicide and the remaining two were background soil samples, soil similar to that suspected of contamination, but is not itself contaminated and is used to assess the ability of the land to support plant life. Preparation began for this bioassay immediately. Two environmental chambers, set with a relative humidity of 70% ± 10%, a day temperature of 80 degrees Fahrenheit, a night temperature of 50 degrees Fahrenheit, and a lighting period of 16 hours at 2000 ft c, were to be used to house the plants. Because of a lack of chamber space, though, due to a previous test yet to be completed, the bioassay was delayed for a week.

On 3 July 89, several pinto bean seeds and sorghum seeds were set out in petri dishes covered by damp paper towels to germinate. On 5 July 89, the soil samples were ground up, sifted, and placed in 235 mL medical cups (8 per sample + 4 controls). By the 6 July 89, enough pinto bean and sorghum plants had sprouted, so the bioassay was begun. The pinto beans and sorghum seeds were planted, 4 per cup and 5 per cup, respectively. For the remaining cups, a laboratory control soil was used and pinto beans and sorghum seeds were planted. Then all the cups were watered with 50 mL dechlorinated water, placed in the environmental chambers, and the date, time, temperature, and humidity were recorded.

On each of the next 14 days, the date time, temperature, humidity, number of emerging pinto bean and sorghum shoots, and amount of water added were recorded. The amount of water added depends upon the condition of the soil as well as the plant. On day 14, the plants were harvested; shoot length was recorded for later analysis.

Aquatic Bioassay (24-Hour Screening)

On the 5 July 89, our lab received three wastewater samples (outfalls 001, 003, 004) from K— AFB that were to undergo a 24-hour screening test per NPDES (wastewater discharge) permit; the organisms to be used would be *Daphnia pulex*. Two environmental chambers, set with a relative humidity of 70% ± 10%, a temperature of 20 ± 2 degrees Celsius, and a lighting period of 16 hours at 100 ft c (per EPA requirements, see Appendix B) would be used to house the organisms. Twelve 100 mL plastic cups, washed out with deionized water two days before, were used to contain the *Dapnia pulex*. Two replicates each of control water and 100% concentration were used per sample. On 6 July 89, each cup was marked and filled with its respective concentration. Then the date, time, dissolved oxygen, pH, and temperature were recorded. Lastly the organisms were added, 10 per cup, and placed into the environmental chambers.

At the 24-hour mark on 7 July 89, the same items were checked as above plus the number of *Daphnia pulex* that were alive. The results were entered into a VAX model 11780 computer system. Another wastewater sample from this base (outfall 002) was received 25 July 89 and the exact same procedure was followed except for one important difference: *Daphnia magna* was used instead of *Daphnia pulex*. This bioassay was completed on 26 July 89 and the results were likewise entered into the computer.

Aquatic Bioassay (96-Hour Acute Nonrenewal)

On the 6 July 89, our lab received a wastewater sample from B— AFB that were to undergo a 96-hour acute nonrenewal test per NPDES (wastewater discharge) permit; the organisms to be used would be Fathead minnows (*Pimephales promelas*). Two environmental chambers, set with a relative humidity of 70% ± 10%, a temperature of 25 ± 2 degrees Celsius, and a lighting period of 16 hours at 100 ft c (per EPA requirements, see Appendix B) would be used to house the organisms. Ten 100 mL plastic cups, washed out with deionized water two days before, were used to contain the Fathead minnows. Two replicates each of control water, 25%, 50%, 75%, and 100% concentrations were used per sample. On 6 July 89, each cup was marked and filled with its respective concentration. Then the date, time, dissolved oxygen, pH, and temperature were recorded. Lastly the organisms were added, 10 per cup, and placed into the environmental chambers.

At the 24-hour mark on 7 July 89, the same items were checked as above plus the number of Fathead minnows that were alive. These results were also entered into the VAX model 11780 computer system.

v. Discussion

The results of the soil bioassay are found in Appendix C. The herbicide greatly affected the quality of the soil, as seen in the fact that the plants in the background soil outgrew those in the contaminated soil. Likewise, the plants in the laboratory soil outgrew those in the background soil, thereby assessing the ability of the uncontaminated soil to support plant life.

The 24-hour aquatic screening test had very interesting results. While outfalls 001 and 002 passed the test with 0% mortality, outfalls 003 and 004 failed it with 100% mortality. Furthermore, outfalls 003 and 004 had ridiculously low pH readings, 2.4 and 3.4 respectively (see Appendix D).

On the other hand, the 96-hour acute aquatic test passed with 10% mortality in the control and 25% concentration and 5% mortality in the remaining concentrations (see Appendix E).

vi. Conclusions

As seen from the results of the soil bioassay, a solid conclusion can be drawn: The herbicide runoff did cause some damage to the agroecosystem as seen in the fact that both pinto bean and sorghum plant growth was stunted in the contaminated soil in comparison to the growth rate in the background soil.

In the 24-hour aquatic screening test, there are traces of an acidic substance in both outfalls 003 and 004: this is seen in the low pH readings of both replicates. My guess is that either someone accidently or purposely preserved the wastewater samples of those two outfalls, or this base is disposing of wastes of an acidic nature into these outfalls.

As for the 96-hour acute aquatic test, I can conclude that the wastewater at this base is relatively 'safe' (in EPA terms) because the mortality rate did not fall below 10%.

vii. Abbreviations

- EPA: United States Environmental Protection Agency
- ft c: foot candles; measurement of light intensity

viii. Acknowledgements

I wish to thank the Air Force Office of Scientific Research, Brooks Air Force Base, and Universal Energy Systems in their joint efforts in the formation of the High School Apprenticeship Program which has given me the opportunity for an invaluable educational experience.

Several people deserve to be recognized and to be given a personal statement of my appreciation because I feel that a challenging endeavor cannot be accomplished by only one person. First of all, I wish to thank the officers of OEHL for allowing me to work in their division: Col Herbold and Lt Col Binovi. I would also like to especially thank Lt Becky Bartine, SSgt Carole Wilson, and SSgt Roberto Rolon for all their valuable help, opinions, and patience with me throughout this entire summer program. Without the gracious help of these individuals, my work would have been extremely difficult.

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Apprendices can be obtained from

Universal Energy Systems, Inc.

Fate and Transport

of

JP-4 Constituents

Andrea Perez

Captain John Erving

AFOEHL, Brooks AFB TX

13 September 1989

I would like to share my deepest gratitude to my mentor, Captain John Erving, for all his knowledge and patience, I would also like to thank the AFOEHL staff for all their advice and general hospitality. I also would like to thank the OEHL scientists: Dr Parrish, Dr Lee, Dr Crigler, and Mr Cornell for all their help in explaining how the laboratories work. I also want to thank the other summer hires for being so kind and understanding to my project needs.

My project this summer dealt with the fate and transport of JP-4 constituents in an aquifer. As part of the project I went to the Occupational and Environmental Health Laboratory. In their laboratories I saw how certain compounds were analyzed. I also saw how they tested for hazardous material found in environmental scenarios. In one laboratory, they had a robot taking samples of different fuel oils and to find out if there were any trace contaminants in the samples. In another laboratory, a scientist was researching the history of a hazardous waste site. The scientist compared this information with up-to-date data on that same site and compared the data to see what kind of changes had taken place over a certain time period.

Before I started on my project, I obtained a better understanding of basic chemistry and hydrology. The research began by looking at the characteristics of organic and inorganic compounds (Fig. A). Basically, non-halogenated organics are not as dense as water and halogenated organics are usually more dense than water. JP-4 is a non-halogenated organic constituent.

The four primary physiochemical properties focused on were the aqueous solubility, specific gravity, log octanol/water partition coefficient, and the toxicity of a contaminant (Fig. B). Essentially these factors mean: a) is the compound miscible or immiscible, b) does the contaminant prefer the polar phase or the non-polar phase (i.e. water or carbon found on soil), and c) will the contaminant pose any hazard to human health?

After the physiochemical properties of a compound are defined, then the hydrogeology cycle is mapped (Fig. C). The cycle functions as: a) precipitation is distributed into the soil, b) the water infiltrates the soil and transports the soluble compound into the unsaturated zone, c) with continuous water movement, the water and compound moves further into the unsaturated zone until it reaches the capillary fringe, d) the compound and water pass through the capillary fringe and into the water table e) water and the soluble compound then disperses into the aquifer and then discharges back to the surface to repeat the hydrogeologic cycle.

When a contaminant is in an aquifer, it is important to know the average water level of the aquifer. This is known as the hydraulic head. When there is a change in the water level, a hydraulic gradient is formed. A hydraulic gradient shows a flow of water from an area of higher head to a lower region of the aquifer.

In an aquifer, JP-4 is a light hydrocarbon and, therefore represents a LNAPL's (light non-aqueous phase liquid) (Fig. E). The JP-4 is released into the unsaturated zone where the dissolved portions of the JP-4 are further released into the water table where they spread and form a plume. As the plume spreads, the ground water will pick up the JP-4 dissolved portions and contaminate a nearby drinking water source.

In examining the fate and transport of JP-4, two factors were considered, porosity and soil-carbon absorption. Porosity (Fig. F) is the percentage of rock or soil which is void of materials. An example of this is clay and sand. clay is composed of tight, highly porous material and because of this if a liquid was to be disposed onto clay, the porosity of the clay would be able to hold large amounts of this liquid. If a liquid was to be distributed onto sand, it would go right through the sand because sand is made of loose material at a lower porosity level. Soil-carbon adsorption is the tendency of soil with carbonaceous material to adsorb a contaminant while it is passing through the soil particle. So the more carbon there is in a soil particle, the more adsorption takes place; therefore, less contamination is available. The lower the carbon content of a soil particle the more mobile the contaminant.

JP-4 contains many components and three were selected based on their differences in solubility and K_{OC} values (Fig. G). The three main components used in this project were benzene, xylene, and toluene. To obtain a realistic concentration of these three components in a spill site, laboratory solubility data were used.

The solubility values acquired on the three components were placed in a computer program called MOC (Methods of Characteristics). In working MOC, certain hardware requirements are needed (Fig. H).

This version of MOC also has certain software model assumptions (Fig. H). Basically all these assumptions state that the scenario used in MOC is in the "world of make believe." This means that the hydraulic head is at a perfect state and the injection levels are at exact amounts.

Additionally, MOC has some parameter limitations (Fig. I). While working on the MOC program, it was observed that to acquire an approximate result two factors in the program had to be manipulated. These two factors were the concentration and the steady-state. The concentration is highly dependent upon the Kd factor that is given to a contaminant. Kd is the distribution coefficient. In establishing this figure, the octanol water partition coefficient needs to be multiplied by the organic carbon fraction. As discussed earlier, the organic carbon fraction of soil is proportional to its as the soil-carbon adsorption properties. So the more carbon content in a aquifer, the lower the concentration of the contaminant in the ground water because the contaminant has adsorbed to the soil. A lower carbon content in an aquifer, the higher concentration of the contaminant and this may pose some risk. In the JP-4 scenario, the aquifer is at a steady state. There is also a MOC program that doesn't have steady state, and this is useful for different types of scenarios.

In Fig. J, one can see how the computer program processes the information. Two factors are dealt with in this scenario which are the distribution coefficient and the retardation factor.

The description of the JP-4 scenario used in this program is as follows (Fig. K): a) the aquifer is 100X100 ft^2 with each cell measuring $10^6 ft^3$, b) the actual water amount in each cell was 400,000 ft^3 due to the porosity level of 0.4, c) the hydraulic head is moving downward very slowly from left to right.

The results of the program are as follows. due to the solubility of benzene, it showed the most mobility. Over a period of injection times (concentrations at 15.8 ug/L) the fifth year showed benzene having a plume concentration of 15 ug/L and then it spread even further to a plume concentration of 14 ug/L and finally it spread to a plume of 6 ug/L in concentration. If the injection time was extended, there would be a possibility of human risk because benzene is toxic.

The results of toluene and xylene are as follows (Figs. L and M). Toluene had a concentration of 16 ug/L at each injection period. This resulted in a toluene a concentration of 9 ug/L within five years. If injection of toluene was to continue, a plume might begin to show, but wouldn't be very toxic. Xylene has a concentration of 5.91 ug/L for each injecting period. As a result it would take five years just to establish a concentration of 1 ug/L. If the injections of xylene were to continue, there would be little risk to human exposure.

In conclusion (Fig. N), actual solubility data was obtained and put it into a computer program which scenario. The results calculated the transport rate of the three JP4 constituents that posed the greatest risk to human health due to their toxicity. The Moc model can assist an environmental scientist to predict the fate and transport of a contaminant and its potential for human risk due to exposure.

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Final Job Report

Alan Thomason

My experience going into this job was minimal, at best. The only skills that I had learned on the job previously were the arts of loading flour onto a semitrailer and flipping hamburger meat. I did have one talent, however, that needed some hands-on refining--computer programming.

As soon as I got on the job my mentor, Captain Logan Van Leigh, nestled me comfortably into the VAX computer system. To me, this system was beautiful. I had only the chance to look at a VAX mainframe once but touch--NEVER! Logan got me my own account and there was even a laserjet printer within ten steps. From there he introduced me to nearly everyone in the building. This proved to be very valuable later on when I needed some good advice on the best ways of refining my program.

I could not have begged for better working conditions from any other boss. Although U.E.S. advised me to expect menial, redundant tasks, what I received was enough meat to chew on for the next eight weeks! At first I couldn't believe what I saw--

the output that Logan asked for looked impossible. What I did not realize was that most of the work had been done for me, all I had to do was update it, modify it to accept commands, and link it all together. It looked easy enough - or so I thought.

The technicals of what I had to do became complicated very quickly. First, I had to get the bits and pieces of the program working. Things had been changed extensively since Art Kaminski (a computer wizard who had moved just months before I arrived) had written this material--databases updated, accounts switched around. This is where I had to do some real office jogging. Ken Gabriel, who normally had the job of updating Art's work, gave me all the information I needed. It was really challenging to figure out how the data used for the tables was pulled from the computer.

Once Logan saw the tables materialize, he decided that we would be able to go one step further. The next goal was to link all of the subprograms together.

Linking all of the subprograms together took up about half of my time at Brooks. There were multitudes of problems that had to be overcome. One of these difficulties that turned up over and over was the priviledges of the files. In one instance, I found that I had no priviledges to a file that I created! Ironically, if it had not been for this stumbling block, I never would have discovered the importance of fdl files.

By this time, my understanding of the VAX mainframe had grown enough to make me realize what a vast ocean of potential I was swimming in. Most important of all, however, are the skills I learned searching for the clues that I thought would solve my problem of the day (or hour). In the end, I was able to jump right into the correct manual (one of about twenty or thirty) and extract the information that I desired. Up until that point my only experience was with schoolbooks (useless for any practical work anyway)and PC manuals.

Now that Logan knew my potential he let me loose on the fun part of the program-user friendliness. It was a big relief not having to debug anything for a while, but as I looked over each section of my program I would try to change something around to reorganize it. Sometimes this did not produce nice results.

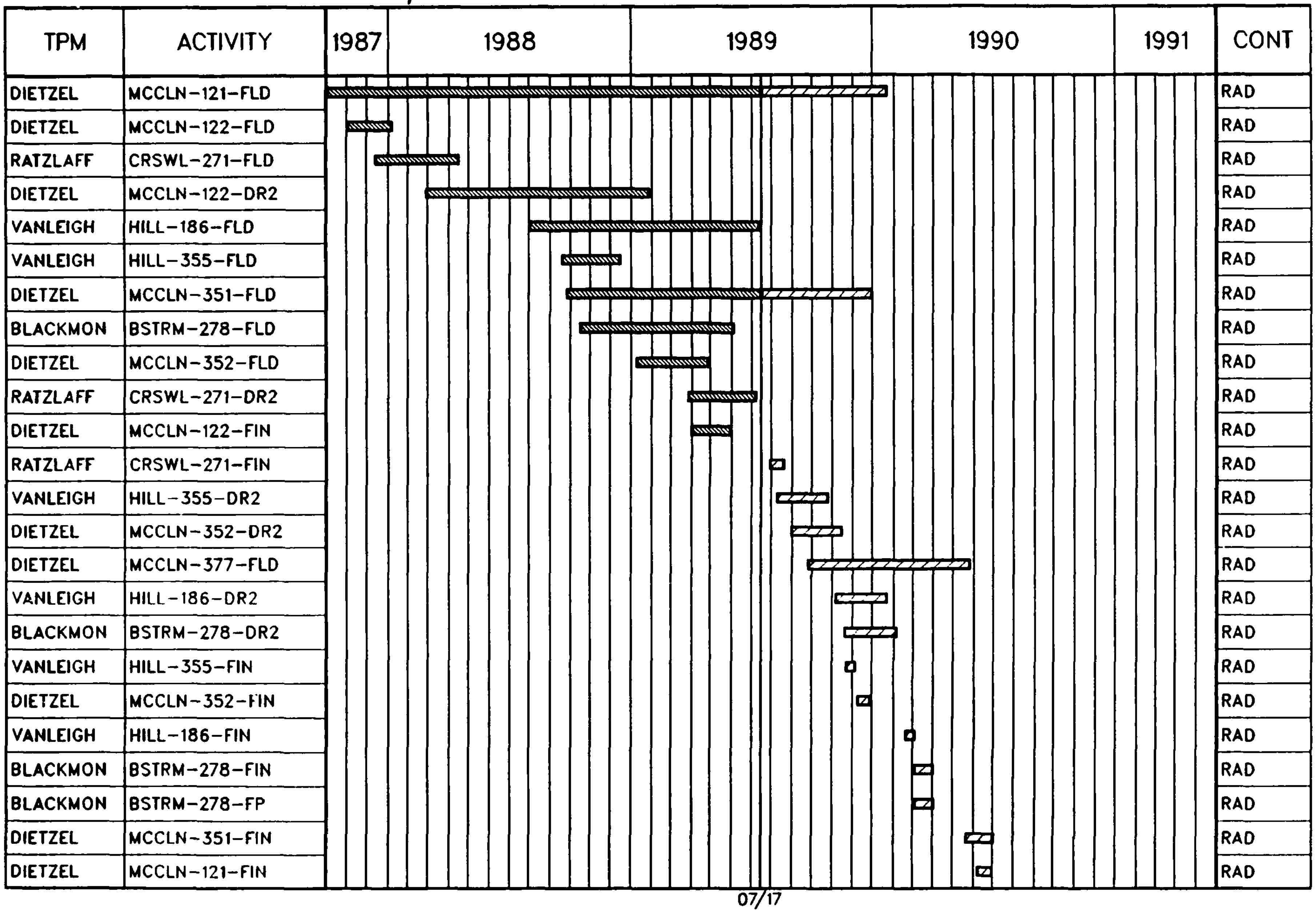
The user friendliness part of the program was in actuality a long, gradual refinement of my work. Over four weeks it really snowballed until I had modified the program to accept a variety of user inputs from custom titles to database selections. The problem here was in deciding how much was too much. I had wanted to keep the program simple, but there were some modifications that were too powerful to ignore. These modifications really made the finished product quite complicated.

The last two weeks on the job were reserved for cleaning up details and documentation. I realized then why my computer science teacher stressed the benefits of organization and good documentation. Other people, for the first time, would have to read my work! To my disbelief, the program and it's documentation together took up an entire notebook.

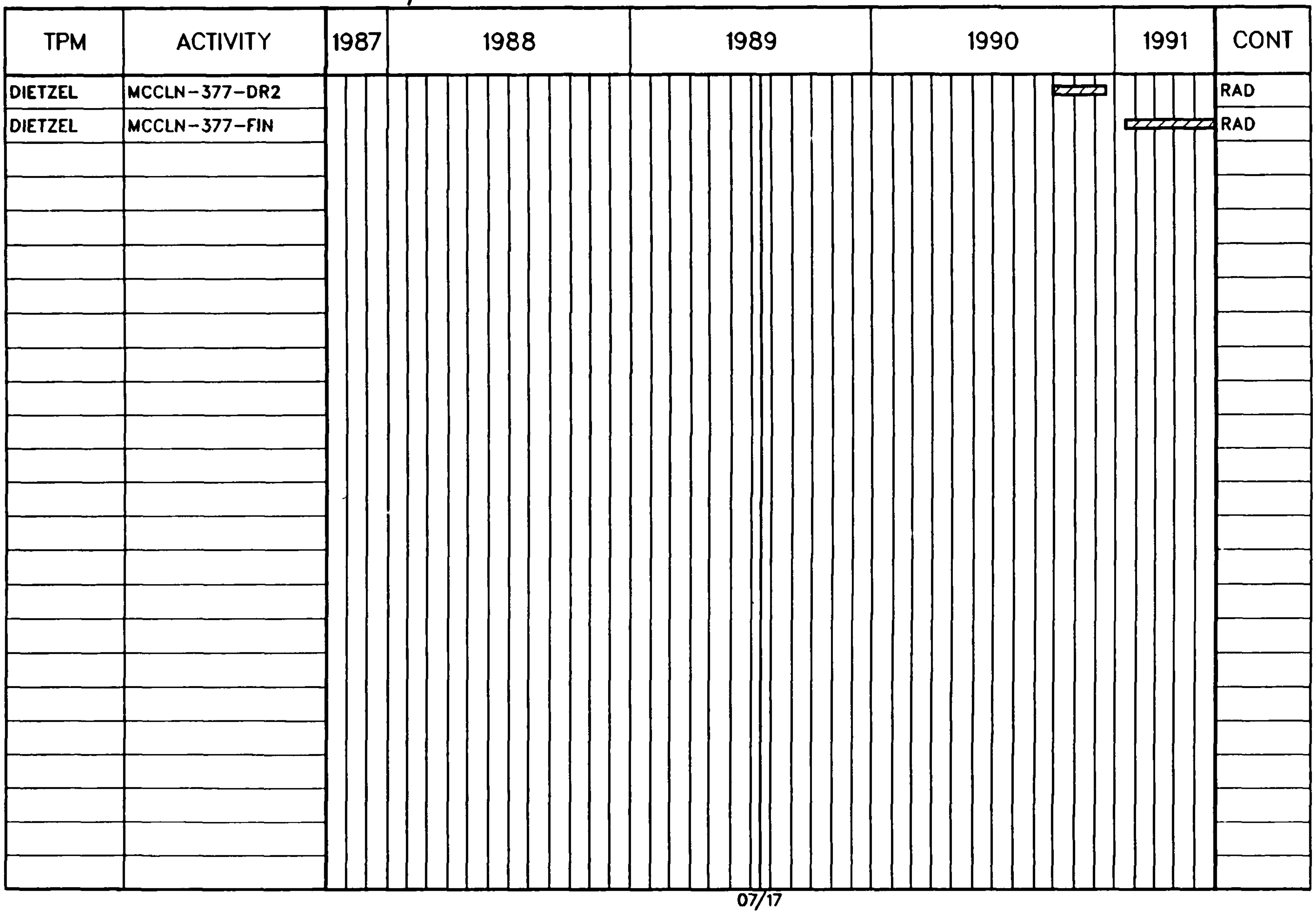
It is my belief that without this fabulous summer job, much theoretical work I had done in high school would have been a waste. It is the practical work I did at Brooks Air Force Base that cemented that knowledge and created the skills I needed to realize my potential. Because of my apprenticeship training I feel I am a much more competent student of the computer sciences.

Before I conclude this report, I would like to extend my warmest appreciation to my boss and mentor, Logan Van Leigh. He treated me as he did everyone else around him, with respect and consideration. Because of his attitude, I actually looked forward to coming to work each day. I became a more efficient worker as well because our relationship conveyed to me that he had placed his trust in me. I doubt that I will work with anyone I respect as much as Captain Logan Van Leigh.

Radian Work Status – July 89



Radian Work Status – July 89



ROME AIR DEVELOPMENT CENTER

A SPECTRUM OF SCIENTIFIC ANALYSIS:
A FINAL REPORT

BY: Daniel J. Abbis
MENTOR: Doug Norton
LOCATION: GRIFFISS AIR FORCE BASE, ROME NY

DATE: August 31, 1989

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I wish to thank the following people for their help and encouragement:

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A special thanks to Mr. Doug Norton for his advisement and support.

1.1 Introduction

My tasks this past summer were designed to give me experience in the optical and computer sciences. My tasks ranged from programming in the computer language of Pascal to the experimentation of an elementary TwymanGreen interferometer.

2.1 Interferometers

My term here started with the experimentation of a Twyman-Green interferometer. An interferometer is a device that divides a beam of light into two or more separate beams of light. These separate beams travel different paths and merge to make interference fringes. Three quantities an interferometer may measure are: difference in optical path, length, and refractive index.

The Twyman-Green interferometer usually uses a Helium Neon laser as a light source (wavelength is $632.8 * 10^{-9}$m). The high intensity and coherence properties of the laser make it the best light source for the interferometer. Coherence means that there is one wavelength and all the waves are in phase. Due to the excellent spatial coherence of the laser, it is highly important that the optics are kept clean. The optics must be clean in order to reduce scatter.

The Twyman-Green interferometer can be made by modifying the Michelson interferometer. It was invented and patented by Twyman and Green in 1916 for the testing of microscope lenses and prisms. It was later modified in order to be able to test camera lenses.

There are two general types of interferometers: division of wavefront and division of amplitude. Appendix A shows Young's double pinhole interferometer. Young's interferometer falls into the category of division of wavefront. The light from the point source illuminates two pinholes. The diffracted light gives the interference of two point sources.

Appendix B shows one possible way of getting division of amplitude. For division-of-amplitude interferometers a beam splitter is used to take off part of the amplitude which is then combined with the other part of the amplitude. The intensity of the interference fringes is greatest when the amplitude of the two interfering beams are equal.

The Michelson interferometer (Appendix C) isbased on division of amplitude. Light from source S is incident on a beam splitter (A1). The light going through A1 reflects off of mirror M1 back to A1. The reflected light goes to M2 which reflects it to A1. At A1 the two waves are partially reflected and transmitted, and some of each wave goes to the screen R.

The Twyman-Green interferometer can be made by changing the extended source in a Michelson interferometer to a point source. The advantage of using a laser over an extended source is that with a laser it is possible to get bright interference fringes.

Appendix D shows a Twyman-Green interferometer used for testing a flat mirror. The laser beam is expanded to match the size of the object being tested. Part of the light goes to the reference surface and some is reflected by the beam splitter to the flat surface being tested. Both beams are reflected back to the beam splitter, where they combine to make interference fringes. The Twyman-Green interferometer can also be altered to test concave and convex mirrors.

The Mach-Zehnder interferometer (Appendix E) is a variation of the Michelson interferometer and it also is an amplitude splitting interferometer. Light goes into the device and is reflected and transmitted by the semitransparent mirror M1. The reflected portion goes to M3, where it is reflected through C2 to the semitransparent mirror M4. Here it combines with the light transmitted by M1 to make interference. The major application of this device is in studying airflow around aircraft and missiles.

Fringes can tell a lot about the surface being tested (Appendix F). If the surface is perfectly flat then straight, equally spaced fringes are obtained. Deviations from the straight, equally spaced condition directly shows how the surface differs from being perfectly flat. Between adjacent fringes the path changes by one wavelength.

3.1 Verona Telescope

The Verona Telescope was built in the early 1970's for the purpose of tracking satellites. I was responsible for a majority of the data collection and assisted in the analysis.

4.1 Pascal

A good portion of my time was spent studying and programming in Pascal. Pascal was created by Niklaus Wirth. The language is named after the French mathematician Blaise Pascal who at age 18 invented the first mechanical calculating machine.

Pascal is a well-structured language. Here are some of its features:

1. The first word in a Pascal program is PROGRAM, followed by the name of the program. The first part of a program is a declaration section for constants, variables, procedures and functions. Every variable used in the program must be declared. The action part of the program starts with the word BEGIN and concludes with the word END followed by a period. Statements are separated from each other by semicolons.

2. Pascal has four standard data types: real, integer, Boolean, and CHAR.

3. An assignment statement in Pascal looks like this:

```
y:=3;
```

Note that a colon followed by an equal sign is the symbol used for an assignment. The statement will cause the variable y to take the value 3.

4. The two input commands are READ and READLN. If you are using Pascal interactively the statement READ(x) will cause the computer to stop and wait for you to type a value

for x. READLN (readline) works the same way except that after a READLN is executed the computer will start looking at the next data line when it reaches the next input statement.

The two output statements are WRITE and WRITELN. The command WRITE(x); causes the value of the variable x to be displayed. After a WRITELN statement the output will be displayed on a new line.

5. Pascal has three types of loops; REPEAT, WHILE, and FOR loops.

6. Arrays are shown by listing the highest and lowest allowable values for their subscripts. For example:

```
VAR mailbox: ARRAY [1..20] of integer;
```

defines mailbox as being a twenty element one-dimensional array, and

```
VAR table: ARRAY [0..10,0..15] of real;
```

defines table as being a two-dimensional array with eleven rows (labeled 0-10) and 16 columns (labeled 0-15).

7. Comments in Pascal start with a left brace and end with a right brace.

5.1 Commentary

I found my term spent at RADC to be most rewarding. It was a great learning experience as well as being very enjoyable. I am very thankful that I was able to participate in this excellent program.

LABORATORY REPORTS

1. Introduction:

In an interferometer (figure 1), fringes are caused by differences in the optical paths of the test and reference beams. In the following experiment report, I shall show how the number of fringes in an interferogram represents the amount of tilt put on the reference mirror by adjusting the micrometer.

2. Objective:

The objective of this experiment is to determine the relationship between the number of fringes in an interferogram and the tilt between the interfering waves.

3. Experimental Set-Up:

It is important to measure the distance between the mirror's micrometer to the fulcrum of the mirror. This distance was measured to be 8.5 cm (figure 2). The maximum resolution obtainable on the micrometer is to the nearest micron.
The interference fringes are displayed on a card that has been marked with a 3 cm. boundary. This boundary is helpful in order to keep a constant distance over which the fringes are measured.

4. Calculations:

If the number of fringes is known, then the amount of tilt between the reference and test wavefronts can be determined. Likewise, micrometer readings taken on the reference mirror can also be used to determine the tilt between the interferring wavefronts. We expect to find a linear relationship between the change in tilt of the reference mirror and the change in number of fringes seen in the interferogram. Below is a sample of data collected during this experiment:

NUMBER OF FRINGES	MICROMETER READING
14	8.125
30	8.140

This linear relation can be seen below:

$$\frac{\text{Delta Fringe}(\lambda)^{*}}{\text{Base Distance}} = \frac{\text{Delta Mircometer Reading}}{\text{Distance to fulcrum}}$$

*Each fringe represents a relative path difference of 2π or one wavelength

$$\frac{16\lambda}{30\text{ mm}} = \beta\,\frac{0.015\text{ mm}}{85\text{ mm}}$$

$$\lambda = 632.8 * 10^{-6}\text{ mm}$$

$$3.371 * 10^{-4}\text{ mm/fringe} = 1.764 * 10^{-4}\text{ mm/fringe}$$

$$\beta = 1.888 \cong 2$$

This value of (β) is expected to be 2, since the reference wavefront travels to and from the mirror. Although the number of fringes are countable, this measurement's accuracy is approximately +/- $\frac{\lambda}{2}$.

5. Conclusion:

The amount of fringes directly represents the amount of tilt put on the reference mirror. Figure 3 shows the relationship between the number of fringes of tilt and the reference mirror micrometer reading.

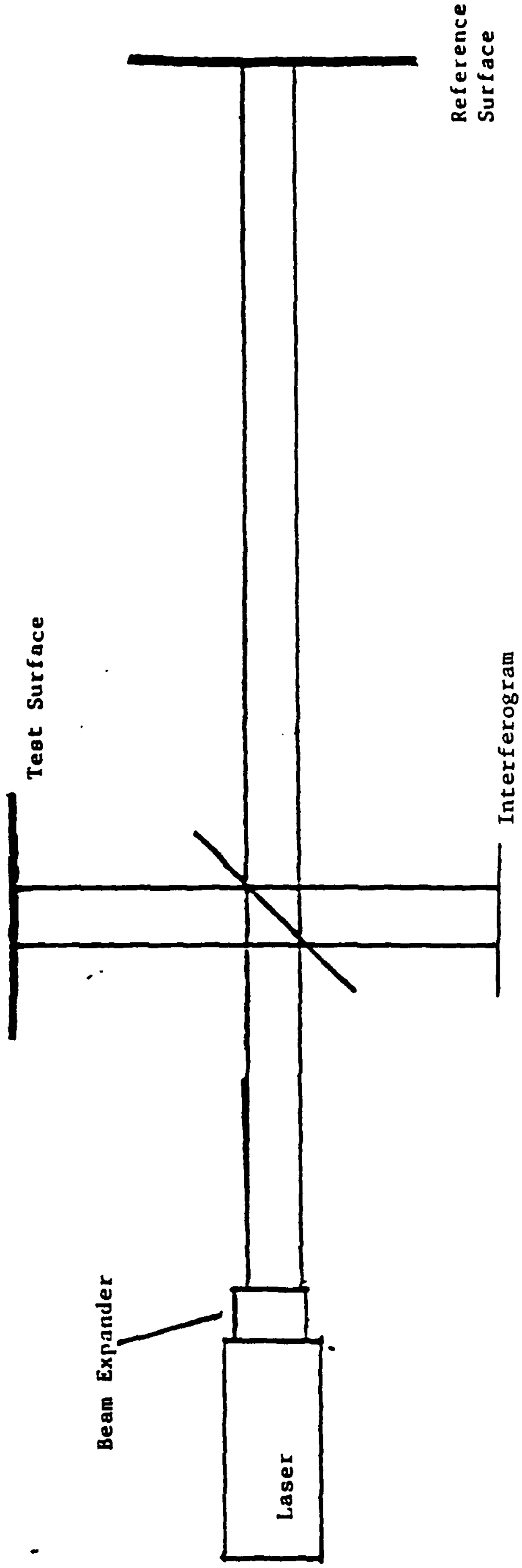
Reference Surface
Test Surface
Interferogram
Beam Expander
Laser

Figure 1

MIRROR DIMENSIONS

Note: All dimensions in inches unless otherwise

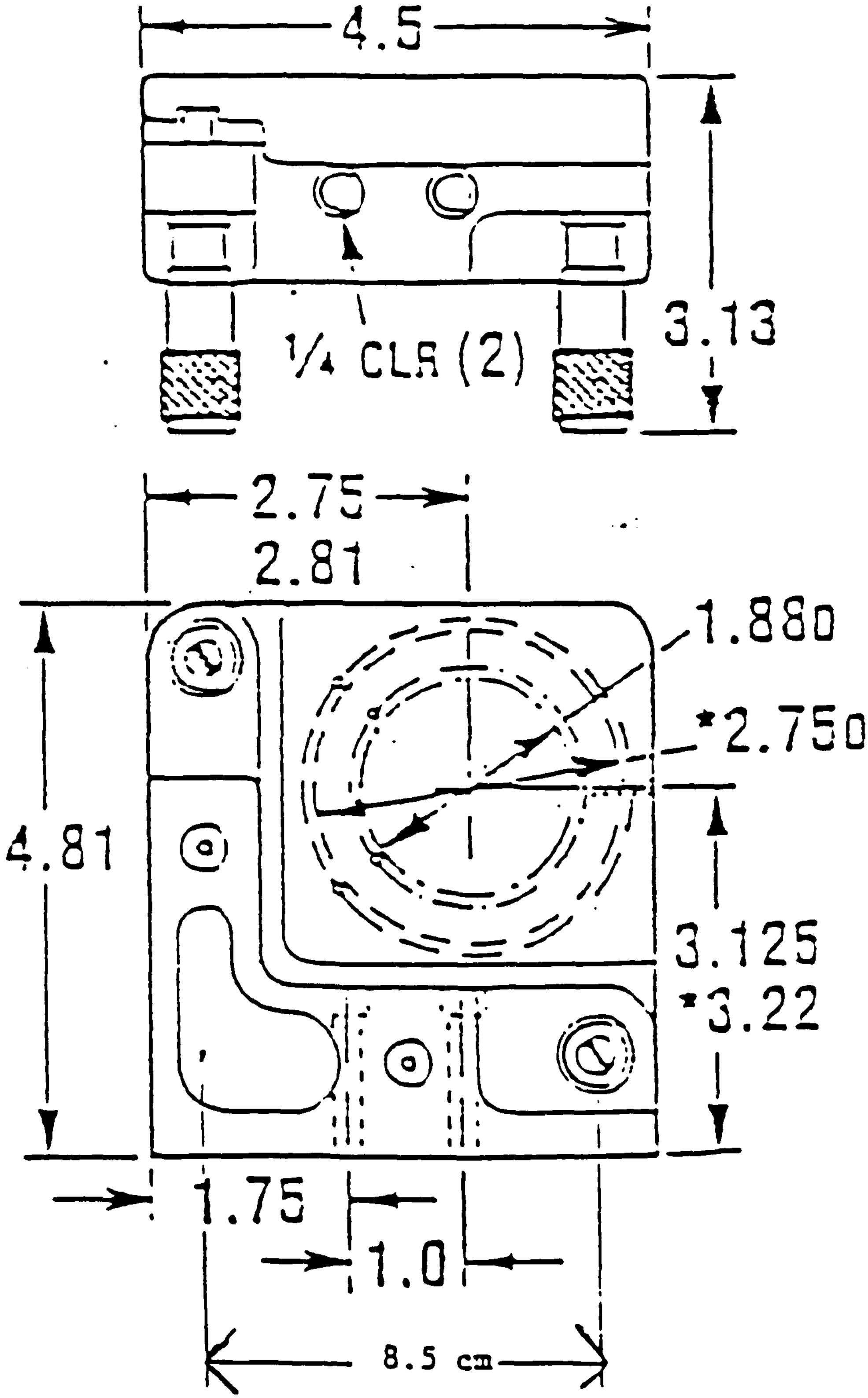

Figure 2

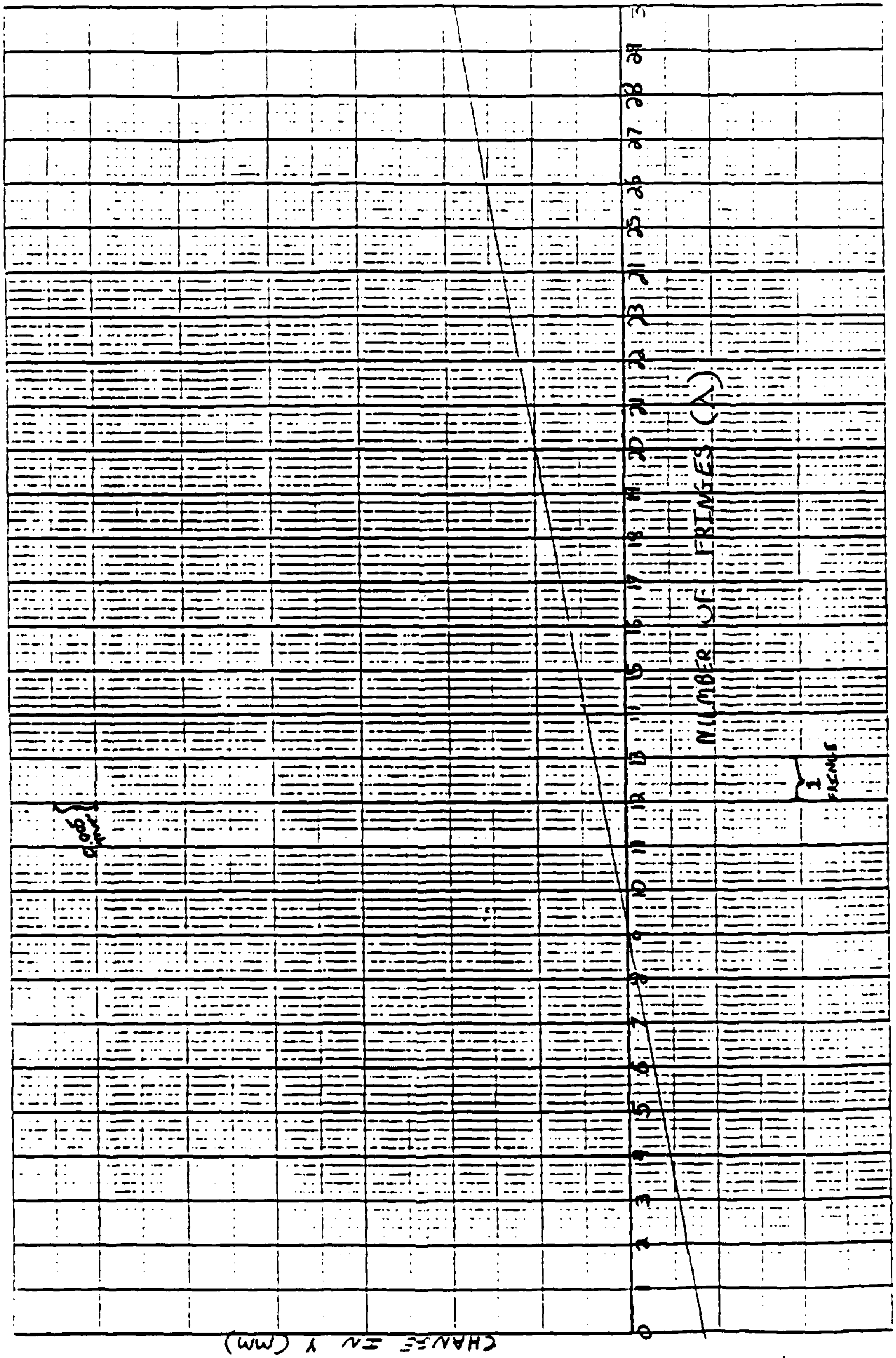
NUMBER OF FRINGES (λ)
CHANGE IN Y (MM)
1 FRINGE
0.006 mm
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

Figure 3

Apprendices can be obtained from

Universal Energy Systems, Inc.

Software Q & A: A Study in Computer Testing

by
Matthew Anderson
RADC/IRDW

Lisle Sanborn, Mentor
RADC/IRDW
18 Aug 1989

Acknowledgements

The summer has proved to be an experience in learning and understanding computer science. I would like to thanks everyone in IRDO, especially Johnathan Gregory, Andrew Hall, William Dyer, and Richard Simard for letting me use their room for those five weeks, everyone in IRDW, Patricia Langendorf, Stanley Damon and Lisle Sanborn, my mentor for introducing me into the world of computer science and to anyone whom I've regretfully forgotten to mention.

General Description

During the past summer I have been researching Computer Testing. Testing is an important part in the life cycle of a computer system, especially when the user environment needs to run at 100 percent all the time. Computer testing basically is a process of exercising and evaluating a system component (either hardware or software) by manual or automated means to verify that it meets specific requirements or differences from the expected results. To familiarize myself to computer testing my first chore was to read the Government and Military Standards on computer testing. Each standard laid the correct procedures of planning a computer testing effort. The standards specified the specific documents that are needed to be written, tests to be run, procedures for problems with tests and much more. Although it may sound difficult to understand at first, testing is almost a daily chore. For example testing the bath or shower water by turning it on and inserting a measuring device, usually your finger. If the water is to hot, you usually adjust the shower knobs and do the same thing again. Testing a computer system can be just the same.

Detailed Description

For example the Computer-Aided Tactical Information System / Selective Imagery Dissemination 88 (CATIS/SID 88) computer system which was the object of my detailed research. The CATIS system was developed for:

a. Establishment and identification of exploitation requirements.
b. Selection and imaging distribution of available imagery for satisfaction of exploitation requirements.
c. Exploitation support in Imagery Interpretation Report (IIR)

item creation for requirements satisfaction.

d. IIR dissemination.

e. Maintenance of data base currency.

But, my task was to study the testing. There are three divisions of testing that I studied: Hardware, Software, and Test Tools. Hardware test verifies or checks a basic component like the Local-Area-Network(LAN), Printers, Host computers, communication interfaces or hardware configuration. The hardware test objective in the complete system is to demonstrate that the hardware system is operational and ready for software installation. The objectives for testing interfaces is to demonstrate operability of the interface to transmit and receive data in accordance with Prime Item Development (PID). For example, the CATIS system Hardware System test consisted of eight tests. The objectives of the Hardware Tests are to demonstrate that the hardware ready for software installation and final tests. Test Tools allow the user to have the computer enter the pertinent data into the program. This is a faster and more reliable than human means. The purpose is to simulate an operating environment and provide means for observing or measuring various parts of the system in ways otherwise not available. The Test Tools provide terminal communications and data base functions to support Integration, Performance and Validation Testing (IPVT) Different utilities functions as a data base verify which proves the structural integrity of the data base. It also produces a report containing the location and descriptions. Regression and Verification Testing will be performed after the functional improvements, repair or enhancements to the program. Regression and Verification testing purpose is to determine if a change has regressed other aspects of the program and it is usually performed by rerunning a subset of test procedures.

Software testing involves running the software to find deficiencies or `bugs' in the program and to verify that all requirement have been met. For example, the CATIS system was built with several software packages: Host Applications (Host Applications), Communications (Comm), and Terminal Support Software (TSS). These packages can each be broken down into units, the smallest testable portion. Each unit can be integrated into a larger unit for more testing until the final system has been tested. That is called levels of informal testing, for example: Unit, Computer Software Components (CSC) Integration, Integration, Operational and Acceptance. To ensure that each package runs correctly, different types of tests are run on each package. For example, the Terminal Support Software formal tests are the Distributed Control Test which checks management subfunctions. This is not the only test run, for the TSS there are four tests with close to three test cases(a further breakdown of the original test) and even more test case procedure. As each part of a program is broken down to units so is the test broken down to handle the unit. To ensure that the tests simulates the user environment correctly, the tests are planned for logic and consistency.

Results

The result of eight weeks of intense studying has paid off in learning a lot about computer testing. Although software testing was the object of the summer to fully understand testing, testing throughout a system was tackled. I understand testing enough to be able to draw analogies to personal every-day life. Although running into a computer system with problems is not something that happens everyday on the street, parallel versions of testing can be drawn to everyday life. For me if I can get practical uses out of a learning experience, I will be happy.

Other Interesting Lessons

My second assignment was to study the CATIS 88 testing. The three filing cabinets full of documents looked ominous at first, but once I realized that only one- third of them were one testing, I breathed a sigh of relief. Although it was pretty impressing to my friends that I had to read three filing cabinets of Government documents in five weeks, that some were just left in awe. Although I am uncertain on my possible future as an Engineer (pursuing other many interests), this summer has been a great window to the computer science world.

Bibliography

GOVERNMENT DOCUMENTS

File Num.	Name	Date	Doc. Num.
13	Hardware System Test Record	04-88	D4239248 A
14	Hardware Test Plan/Procedure	01-88	4239226 B
28d.	Test Tools	02-89	D4235203 C
36	Software Test Plans		
c.	Test Tools CSCI	07-88	4239263
f.	Terminal Support Software	07-88	4239268 C
37	Software Top Level Design Documents		
d.	Test Tools CSCI	02-89	D4239209 A
42	White Paper SCI Testing	08-87	4239298
45	Software Detailed Design Documents		
c.	Test Tools CSCI Vol 1	02-89	D4248115 A
49	Software Test Descriptions		
a.	Test Tools CSCI	01-88	4239239 B
63	Hardware Test Report	04-88	4248046
66	Software Test Procedures		
c.	Test Tools CSCI	10-88	4248149 B
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73	Verification Cross Reference Matrix	06-88	4248178
75	Software Test Plan		
a.	Test Tools Inc 2	11-88	4248176 A
b.	System	11-88	4248170 A
c.	IPVT	11-88	4248171 A
d.	Terminal Support Software	06-88	4248172
e.	Host Applications	06-88	4248169
f.	Communications	06-88	4248168
131	Increment 1 Test DRR Vol 1	08-88	4248166 A
a.	Vol 2	07-88	4248166
161	System Security Test Procedures	02-89	4248214 A
167	Software Test Procedure for the Site Acceptance Test	11-88	4248233
170	Software Test Reports		

a.	Host Applications CSCI Vol 1-3	09-88	4248234
e.	Terminal Support Software CSCI	08-88	4248182
f.	Test Tools CSCI	10-88	4248180
171	DRR Dispositions		
	Software Test Plans Inc 2	11-88	4248228
173	Software Test Descriptions		
a.	Integration, Performance and Verification Test Inc 2	12-88	4248199
b.	Communications CSCI Inc 2	12-88	4248201
d.	Test Tools CSCI Inc 2	12-88	4248203
e.	System Inc 2	12-88	4248198
175	Software Detailed Design Descriptions		
a.	Test Tools CSCI Inc 2 Vol 1 of 2	12-88	D4248237
	Software Test Description		
	System Inc 2	12-88	4248198
	Software Test Plan		
	Maintenance Releases Inc 1	05-89	4248256

***NOTE: Some documents are not included because of the unaccessibility or needed security clearance at the time of the research. Proper file numbers were not available on some documents using the latest ascension list because of recent printing of the document.

GOVERNMENT STANDARDS

JOINT REGULATION, dtd June 1984 - developed by JLC/CMS Subgroup for user on DoD Programs
DOD-STD-2167 (Updated to 2167A)
MIL-STD-483
MIL-STD-490
MIL-STD-1421

NON-GOVERNMENT ARTICLES

Software Project Management
Testing
Stephen M. Thebaut, University of Florida
CE-SPM-02-03-02
1989 Carnigie Mellon University

Systematic Software Testing
Methodology, Techniques and Tools
Version 2.2
Seminar 1989
Software Quality Engineers

Neural Computing

by

Carolynn Bruce

Rome Air Development Center/ COTC
Universal Energy Systems
Dr. Raymond Liuzzi
August 31, 1989

Working at RADC has been a very pleasurable experience. I would like to thank everyone in COTC for their time and help. A special thank you is sent to Dr. Ray Liuzzi, for without him, this could not have been possible. You have all taught me a lot in many different areas, and for this you are greatly appreciated.

I. Introduction

Neural Computing is a complex study that has developed within the past five decades. In general, the concept from which this was drawn, came from the human brain. It is thought that if a scheme of nerves and connections, such as those that form the mind, can learn, recognize, and remember events and functions, an array of wires light beams, and processing elements, in the form of a computing machine should do the same. Much progress has been made thus far, but it will be nearly impossible to completely mimic the brain.

This research is intended to provide an overview of neural computing, how neural networks relate to the brain functions, and the possibilities of new neural computing architectures.

I feel it would be most useful to initially give a brief description of the organization of the brain, and compare it to that of artificial neural networks. In this way, the reasoning behind the architectures of such systems can be fully appreciated. Next, the application of neural computers will be examined. This is followed by current research areas of neural computing and recognition of a tool for neural research called MacBrain.

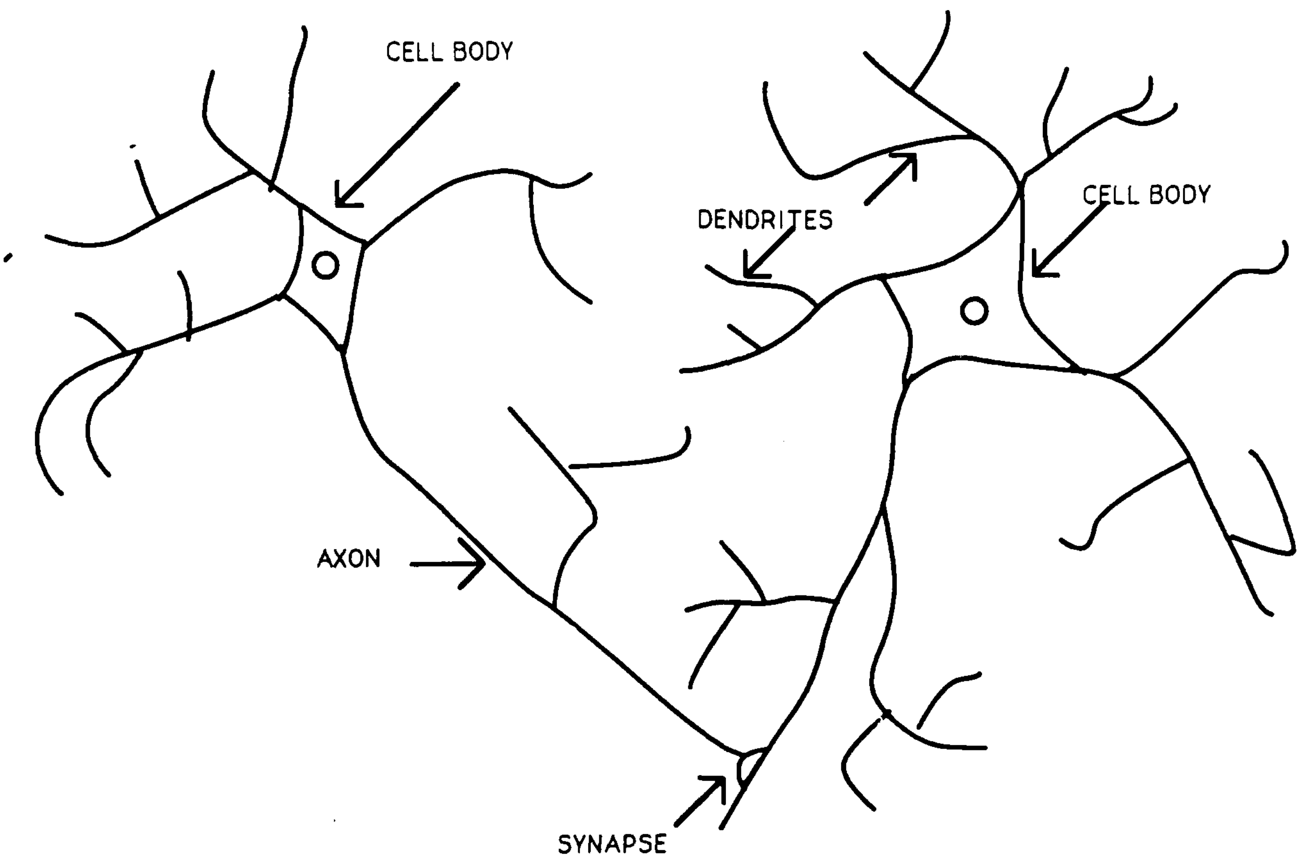
Finally, the future of neural computing in the areas of optical neural systems and parallel processing will be discussed.

II. The Human Brain

The human brain is a very complex and unique system. This three-dimensional maze of nerves holds the power to solve all problems and answer all questions. Scientists do not yet know exactly what causes one to see and hear, to learn skills and remember events, or to plan actions and make choices. They do know, though, that the manner in which the mass of neurons are interconnected contains the solution.

It is estimated that over 10^{11} neurons share in approximately 10^{15} interconnections throughout the body. (Wasserman, Neural Computing p. 12) Each of these neurons holds unique characteristics. An individual neuron is not especially smart, but when one is linked to a network of neurons, it becomes quite intelligent. Their ability to receive, process, and transmit signals comprises a communication system within the body.

Neurons consist of three sections: cell body, dendrites, and the axon. [Figure 1] The cell body regulates the activity within the cell and generates nerve pulses. Dendrites serve as receivers as they take in signals at the synapse. The axon then transmits these signals to the many different neurons. (Wasserman, Neural Computing p. 192-4) The communication process begins as the dendrites extend from the cell and receive the signals from the synapse. These inputs are then connected to the cell body. There they are all summed. Some inputs tend to excite the cell, where as others tend to inhibit its firing. When the cell exceeds a certain excitation threshold, the cell fires, sending a signal down an axon to another neuron, thus repeating the process.



BIOLOGICAL NEURON
FIGURE 1

III. The Artificial Neural System

Artificial neural networks perform in much the same way as their biological model. The structures and terms may be the same, but the manner in which it is organized may, or may not be, similar to that of the brain.

A neural network consists of a collection of processing elements (neurons), each of which has many input signals, but only one output signal. Every connection entering a neuron has a weight assigned to it. It is used to increase, decrease, or possibly change the sign of the signal of an input.

When a signal enters a network, the *neuron multiplies it by the* weight of the entering connection. It then adds all of the answers and multiplies the total by a nonlinear function to give a single output. (Hecht-Neilson, "Neurocomputing: Picking the Human Brain" p. 40) Each processing element directly affects the result of the entire system, since each output becomes the input to many others.

The output of the network determines whether the neuron is ON, OFF, or of a state in between. It represents the learned information in the system. If a network is ON, or in an "in-between" state, the neuron will fire a signal, therefore continuing the process. If it is OFF, the neuron ceases fire. Learning is a process in which the synaptic weight changes in order to cause a network to fire a signal.

IV. Teaching Neural Networks

A neural network is trained so that application of inputs produces a desired or consistent output. It does this by naturally setting up associations and categories. Therefore, instead of relying on rules, artificial systems learn from a series of examples of desired behavior. It forms its own internal rules, and perfects them by comparing its results to a paradigm. The network literally teaches itself how to do a task.

Two methods are used when a neural network teaches itself. Supervised training is the first of these. In this, both input and desired output are sent through the system. After a trial, the network compares the outputs to that desired for the corresponding input. It corrects any error, changes the weights, and sends the same input through the setup. This process continues until the error has minimized to an acceptable level. The second type of training is called Unsupervised or Graded Training. As in supervised training, input data is supplied. The difference is, the desired data is not given. After each trial, the network is "graded" or given a performance score to tell it how well it is doing. Eventually, the system will learn to recognize the pattern. In either case, supervised or unsupervised, the network is ready to process and learn genuine material.

VI. Current Research

Neuroscientists have concluded two major objectives for the experimentation of neural computing. Primarily, the goal of much of neural net research is to understand the complexity of the human brain, its physiological and psychological functions, and to gain insight on to how the brain deals with problems it has to solve. Secondly, Artificial Intelligence Researchers would like to produce a computational system that mimics and performs like the brain.

At present, there are thirteen best known neural networks. On of the first to be introduced was Perceptron in 1957. Frank Rosenblatt invented this machine that recognizes typed characters. Due to its inability to recognize complex characters and its sensitivity to difference in scale, translation, and distortion, it is rarely used today. The easiest network to learn, the Bidirectional Associative Memory Network (BAM) which was introduced in 1985. The BAM stores and recalls associations that are learned by summing matrices and transforming that sum into a single binary output. Other networks include: (1) Boltzmann machines, which simulates the behavior of physical systems; (2) Neocognitron, which recognizes handwritten characters; (3) Avalanche, recognizes speech and teaches motor commands to robotic arms; and (4) Hopfield networks.

The usefulness of these networks can not be seen fully without a computer. Currently there are many different types of hardware on which neural nets can be implemented. Neurocomputers are just this. The coprocessor is a board that looks like any other circuit board that plugs into a host PC through a shared data bus. There are approximately fifty different types of hardware being developed for future use. In this host of hardware, three physical forms are found: electronic (everything consists of electronic devices and circuitry), electro-optical (optical signals link electronic processing elements), and entirely optical (light signals link optical processing elements made out of a non-linear optical material).

NETalk is a neurocomputer that has learned to speak English. It started with an input of written text and the ability to drive a speaker. There were no rules for matching letters with sounds, instead, algorithms were used. Along the way, it taught itself pronunciation rules. At first, NETalk could only babble, but after a day of training it could read text with about 90% accuracy. (Allman, "Designing Computers" p. 64)

When researching at RADC, I had the opportunity to use an neural network simulation program entitled MacBrain. (Chait, Mac Brain p.1) This tool allows the user to design a model and apply it to a problem. I found it very user-friendly and tremendously helpful in understanding how neural nets work. Mac Brain has four tutorials that represent different network models. These introduce one to the various features and applications c' the system.

The first of these tutorials is a simple clock. This is an example of a simple, non-learning network. It introduces the icons and illustrates their purpose. The second tutorial becomes a bit more involved.

"The Animal Expert" processes information about different types of animals. In this, the user toggles one or more feature units and allows the system to run. The network will produce an answer based on the characteristics described. This gives an example of a connectionist network.

The third tutorial demonstrates the Hopfield Network. This is a simple character-recognition network that uses the Hebbian rule to recognize numbers. In this program the system is taught a number of patterns asynchronously and then is asked to recall them.

The final tutorial uses back propagation to solve the XOR Problem. It requires an output to tell whether one or two inputs is on. This is done by using hidden layers that develop their own internal weights and representations.

Beside these four models, MacBrain can solve various problems, analyze data, and make decisions. Because this system works in parallel, information can be processed very quickly.

With these types of neurocomputers and tools, scientists are trying to use optics and parallel processing. Optics seem to be a promising technology when constructing communication operations in neural networks. The operation of the human eye suggests that multiple beams of light can pass through a lense, or prism, and still remain separate. Two beams of light, unlike a pair of current carrying wires, can cross without affecting each other. (Abu-Mostafa, "Optical Neural Computers" p. 88) Optical elements, unlike silicon chips, can be wired in three dimensions. By knowing this, large numbers of processing elements can be connected without limitation. Such interconnections can simulate the complexity needed for neurocomputing.

Optical neural computers consist of two main components. The first is a two-dimensional array of optical switching elements to simulate neurons. The elements switch states depending on the states of the elements to which they are connectea. Each element can be interconnected to all others by the light beams. The second component is a hologram that specifies the connections among the elements. Holograms seem to be the most promising device for establishing optical connections. They are best known generalizing three-dimensional images, but they also represent an effective technique for recording and reconstructing the intensity of a light beam. Another advantage of planar holograms is they can direct a light beam on one side of it to any point on the other.

Unfortunately, with such a promise for the future, there are limiting factors involved when applying optics to neural computing. Optical devices have their own physical characteristics and they often do no match those of neural networks. This causes the images from optical neural nets to be poor. The alignment of the light sources is also critical. If they are not lined precisely, the network will not function properly, if at all. A major weakness of optical neural systems is the cost of production. Additional research should be directed towards overcoming these limitations.

Another direction for neural computing is parallel processing. Parallel processing is a type of information processing that transfers data simultaneously rather than sequentially. (Dictionary of Computing p. 270) Parallel systems have four main advantages over sequential architectures for neural computing. First, the price-performance ratio of parallel systems versus sequential systems is higher. Next, performance is a critical factor. These supercomputer systems can work at rates much faster than conventional computers. Third, parallel systems are fairly easy to expand, allowing scalability and distributed system advantages for neural computing. Finally, parallel systems are inherently fault tolerant, which can be a critical advantage for neural computers.

There are two obstacles causing a delay in the extensive use of parallel systems. First, a system needs to be devised that can take full power advantage of parallel processing. Along with this, parallel programming languages, compilers, and programs need to be developed and taught. Few engineers have extensive experience with non-sequential languages. The second drawback involves existing software. New systems will have to be designed to offer compatibility with existing ones, but they also must be designed with efficient parallelism in mind. Both tasks will prove formidable to overcome unless quality research is not begun immediately.

Parallel processing can provide a new way of thinking about perception, memory, and learning for neural computing. It is hoped that a massively parallel system of computing circuits and the use of optics can be developed to increase neural computing capabilities tremendously. It is thought that because parallel processing will dominate computer technology in the next decade, its impact on neural technology will provide a capability to process very large amounts of data. This will enable a capability to process, in real time, very large data/knowledge bases using neural computing as the basic execution model. However, additional research must be followed in this area to define data models, representations, and architectures.

V. Application of Neural Computers

Neural networks model the way the brain encodes and processes information. They recognize human faces, teach themselves to read and speak, learn from experience, and perform a variety of other pattern-recognition tasks that have baffled conventional computers. Today, applications of neural nets are under development in three major categories: data analysis, pattern recognition, and control systems. The financial industry uses neural net experimentation to assess problems with credit line usage, loan applications, or credit applications. The system is given relevant data from an application form. It then judges, based on the examples on which it has been trained, whether the applicant is a credit risk or not. Neural nets can also be applied to very large databases, such as those predicting a new product.

The second biggest application of neural networks--pattern recognition--can be applied to industrial inspection, target recognition, medical imaging, and speech recognition, as well as a host of other image-analysis applications, that include: seismic data, earth satellite images, and handwritten character reading. Recognizing human speech is a challenge that makes the computer identify speech, convert it to phonetic representations, and translates it into written text. Neural nets have only recently broken ground on image recognition.

Other promising applications include: radar, sonar, and electronic warfare signal identification, adaptive systems ranging from flight to manufacturing controls, image compression, detection of strategic weapons by means of satellite sensors, stealth aircraft detection by infrared search-and-track systems, and photo interpretation. All of these are possible because the neural network can discriminate between signals and make initial choices of phonemes.

Neural networks offer the opportunity of training a human level of perception and pattern recognition into a computer system. This is all possible because the net, which mimics the actions of the brain cells, can learn and adapt by themselves. The network can easily switch from one task to another because it is not so much programmed as it is "trained". Since neurocomputers are not programmed, then, there is no need for software or software development in the forms in which we have grown accustomed. Therefore development time and cost is lower, and networks can be implemented in simple hardware.

Neural networks have many important features and advantages, for distributed computing. In a local representation network, each node represents a word or concept. In a distributed network, nodes do not have a simple meaning, but rather an individual concept is represented by a pattern of nodes. This offers the advantages of automotive generalization and insensitivity to damage. In a local representation if a system loses a node representing "father" for example, it loses the concept of "father". In a distributed nature, in order to lose a concept all the nodes representing it must be lost. This has lead to the assumption that the brain has a distributed nature.

Interconnections among the networks many processors, linked like braincells, are modified so that a particular input will produce a desired result. The computation is spread over many connections, thus the network related an input pattern to an output pattern in a statistical rather than exact manner. The network can therefore process incomplete data. such as half of an image, just as the brain can. A network can also recognize patterns despite noise.

Neural computers produce answers that are not always the very best, but are pretty good. With some tasks, perfection may not be worth the extra time and effort spent, especially if there are good answers that can be found quickly. Absolute accuracy may not always be ideal. Reaching a good working solution fast--rather than struggling for a long time for the best answer--may be more effective in finding the shortest way to route telephone lines or creating a compact design for a microchip, for example. Speed would also be more important than perfection for machines designed to recognize patterns and make generalizations. (Allman, "Designing Computers" p. 62-3) Because computing can be done simultaneously by mass parallelism, tasks can be performed much faster by neural computers than by digital ones.

The benefits of artificial neural systems also include: reduced design time as compared to "rule-based" systems, adaptive, trainable, naturally massively parallel, and highly fault tolerant systems. Also, neural networks do not crash like digital computers when damaged. Instead, they deteriorate and can be fixed by relearning.

The disadvantages and problems of neural networks are far outweighed by the advantages. "A neural network represents a dynamic system that can be modeled as a set of coupled differential equations. A system like this is potentially unstable. Small perturbations of the weights may result in uncontrollable oscillations, bursts, standing and traveling waves--even chaos!" (Till, "Computer System Architecture" p. 60) Also, like humans, computer based neural networks make decisions based on past experiences rather than by following a series of rigid instructions. But neural nets often can not "explain" why they arrive at a given decision. This limits their usefulness, if only because many people find it hard to accept answers from a computer. (Marbach, "Teaching Neural Networks" p. 69)

VII. The Future of Neural Computing

The study of neural computing began with Hopfield's "crude board". It is said to be one of the first real neural networks. In 1937 Claude Shannon stated that symbolic logic could be simulated in the on/off states of electronic switches. In the early 1940's, John von Neumann showed how a machine could store data in these electronic switches and use a processor to perform sequential operations. In 1945 McCulloch and Pitts published the first study of artificial neural nets,.and in 1947 they explored network models for pattern recognition. In 1955, Herbert Simon and Allen Newell invented a "thinking machine." (Allman, "Designing Computers" p. 59-60, Wasserman, Neural Computing p. 27) Now, we have the ability to use massively parallel computers for simulating neural networks. Since the concept of neural computing has been around for a number of years it is now time to predict how useful neural computing will be in the future.

Neural networks have the potential for making computers do things they can not do today, to make computers much easier to use, and to eliminate some of the tedious programming and reprogramming they require now. In the future, we can expect a system that would be ideal for spacecrafts, automated power plants or large, complex information data storage, where a sudden breakdown could be catastrophic. New technologies, such as optical processing, high density semiconductor networks, and "spin glasses" offer an unforeseen capacity for high-speed oriented computation architectures. (Kohonen, "An Introduction to Neural Computing p. 5)

The expected growth of such systems will place enormous demands on the innovative software and hardware technologies that can provide random access to various databases. In these systems, data must be constantly programmed, compatibility with other systems is not easily found, and there is a lack of promise that data will be easily available and retrievable. A neural computer could be developed to eliminate these problems, speed up performance, and offer large savings in time and cost.

Much has been written recently about neural networks. Some feel they *will replace all other architectures, such as digital computers.* This is not possible. Tomorrow's neural networks may indeed display an advantage over such tasks as vision and speech recognition, which involves making optimal choices from huge numbers of alternatives. However, like real brains, they will always lag behind the high-speed computational ability of digital computers. Instead, neural computers are seen as a complement to existing systems and should be integrated as useful components.

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1989 UNITED STATES AIR FORCE / UNIVERSAL ENERGY SYSTEMS, INC.

HIGH SCHOOL APPRENTICE PROGRAM

REPORT - VOLUME I

THE EFFECTS OF APERTURE WEIGHTING ON FAR-FIELD RADIATION PATTERNS

Prepared by: Katherine A. De Bruin

USAF Mentor: Scott M. Bolen

Research Location: Rome Air Development Center
Griffiss Air Force Base
Rome, New York

Date: July 7, 1989

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I would like to extend my thanks to the people in OCDS who helped to make my apprenticeship at the Rome Air Development Center so valuable. These people devoted their time and effort to teaching me not only about space radar, but also about how the world really works.

INTRODUCTION

Phased array radars use electronic scanning to provide an increase in performance over conventional scanning systems. These flat-faced radars are comprised of many transmit-receive modules which are able to change the phase of the incoming radiation in order to accomplish beam steering. This advantage allows the aperture of the phased array radar to remain in a fixed position, eliminating mechanical movement and wear.

The Parametric Antenna Analysis Subsystem, PAAS, is a flexible simulation tool that can compute the far-field pattern of generic phased array designs. PAAS is capable of taking many factors into account, including size, feed types, tapers, errors, aperture weighting functions, and element failures. This simulation experiment was designed to show the effects of aperture weighting on the far-field antenna patterns.

The phased array radar in this simulation contains two thousand two hundred and eleven (2211) modules that are distributed evenly over the entire aperture. With uniform weighting each of these modules transmits the same amount of energy. With other types of weighting the energy is not evenly radiated from the aperture. The purpose of this is to create a narrow, focused main beam while reducing the level of the undesirable side lobes. This simulation experiment shows the effects of such weighting functions.

TEST CASE #1

I. PURPOSE

The purpose of this test case is to show the aperture radiation pattern and far-field pattern for an ideal simulation with uniform aperture weighting.

II. SYSTEM DESCRIPTION

Frequency:	1.0 GHz
Feed:	Ideal Space Feed
Dimensions:	Height: 10.0 meters
	Width: 5.0 meters
Elements:	28 Bit Phase Shifters
	Isotropic Radiators
Element Spacing:	0.15 meters apart
	Rectangular Lattice

III. WEIGHTING FUNCTION EQUATION

Not applicable in this test case.

VI. RESULT ANALYSIS

With uniform aperture weighting the main lobe had a directive gain of 44.46 decibels. In the horizontal direction the side lobes were 12 decibels down, and the deepest null was 37 decibels long. The width of the main lobe was 2.87 degrees. The deepest null in the vertical cut was 32 decibels, while the main lobe was 1.15 degrees wide, and the first side lobes were 15 decibels down. The main lobe measurements were made three decibels down from the top of the lobe.

V. SIMULATION RUN FILE

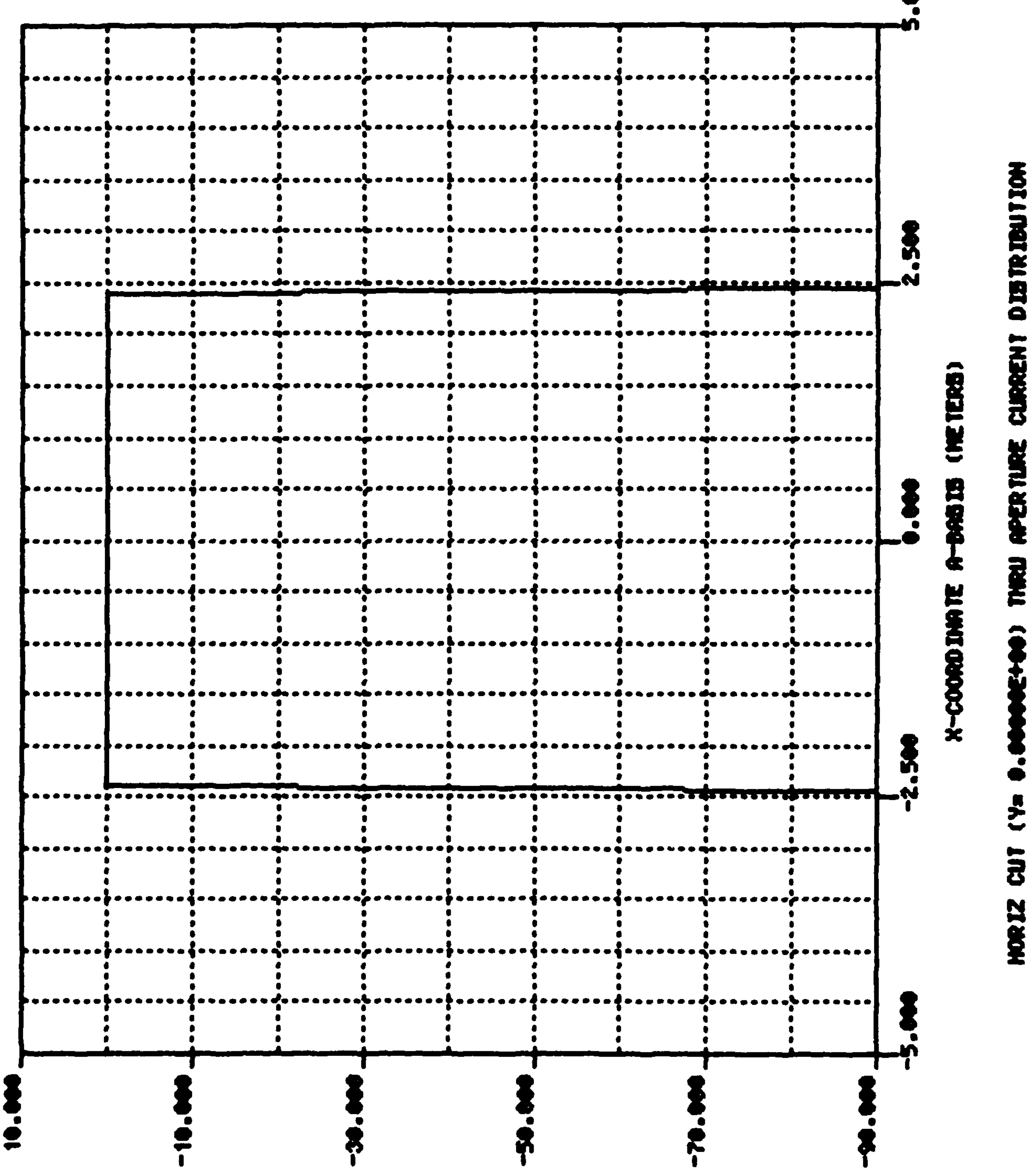
```
SIMSYS
FINST =   1.0000E+00, FOPER =   1 0000E+00,
$
LATTICE
ILTYPE=             1, COLSPC=  1.5000E-01, ROWSPC=  1.5000E-01,
$
RSHAPE
XWIDTH=  5.0000E+00, YHIGH =  1.0000E+01, WTXRAD=  2.4750E+00, WTYRAD=  5.025CE+00,
$
WITSYS
IWTFLG=           0,
$
SPAFED
XNFEDA=  0.0000E+00, YNFEDA=  0.0000E+00, ZNFEDA=  1.0000E+01, XAFEDA=  0.0000E+00,
YAFEDA=  0.0000E+00, ZAFEDA=  1.0000E+01,
$
PLARY
NO
IBSFLG=           0, XBEAMT=  0.0000E+00, YBEAMT=  0.0000E+00, NBITS =          28,
LS3RND=           0, IROFF =              1, ITAPER=              1, DENMAX=  1 0000E+00,
IG4    =          2,
$
XFORM
NO
YES
N2     =          8, TXCENT=  0.0000E+00, TYCENT=  0.0000E+00, TXSPAN=  1.5000E+00,
TYSPAN=  1 5000E+00,
$
TCS
IGRDF =          -1, IBAUD =           9600, ICAPLB=           2,
$
CLOSER
```

VI. OUTPUT DATA

A. PATCUT was used to plot the radiation distribution pattern on the aperture that is seen in figure one (1). Only the horizontal cut is shown since the overall shape of the horizontal and vertical cuts is the same. This command was also used to generate the horizontal and vertical cuts of the far-field radiation pattern seen in figures three (3) and four (4) respectively.

B. PLOT3D was used to plot the three dimensional graph of the far-field radiation pattern that is seen in figure two (2).

FIGURE #1


5.000
2.500
0.000
-2.500
-5.000
10.000
-10.000
-30.000
-50.000
-70.000
-90.000
X-COORDINATE A-BASIS (METERS)
HORIZ CUT (Y= 0.0000E+00) THRU APERTURE CURRENT DISTRIBUTION

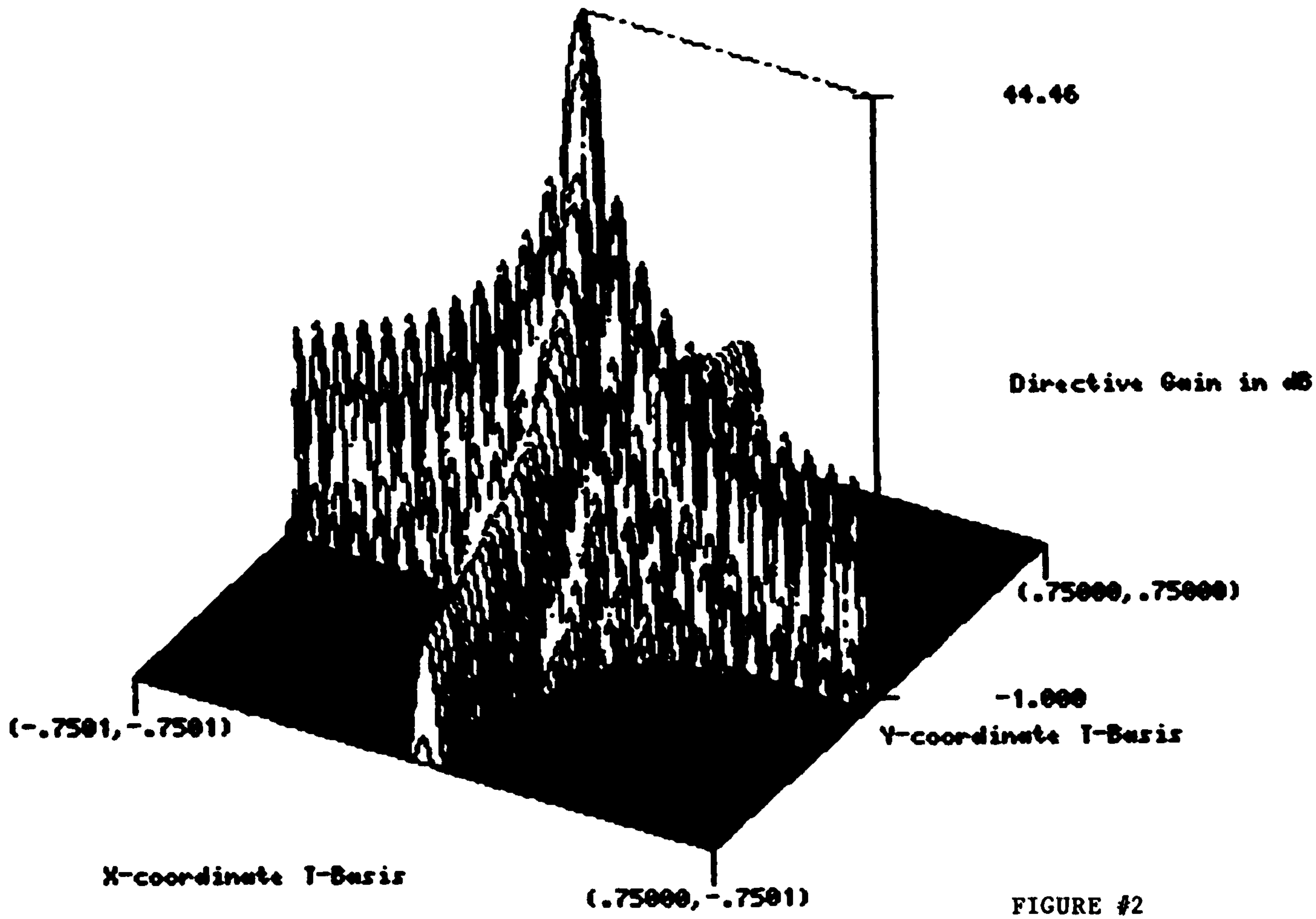


FIGURE #2

Surface Diagram of the Array Factor

THE PEAK DIRECTIVE GAIN IS 44.465DB

FIGURE #3

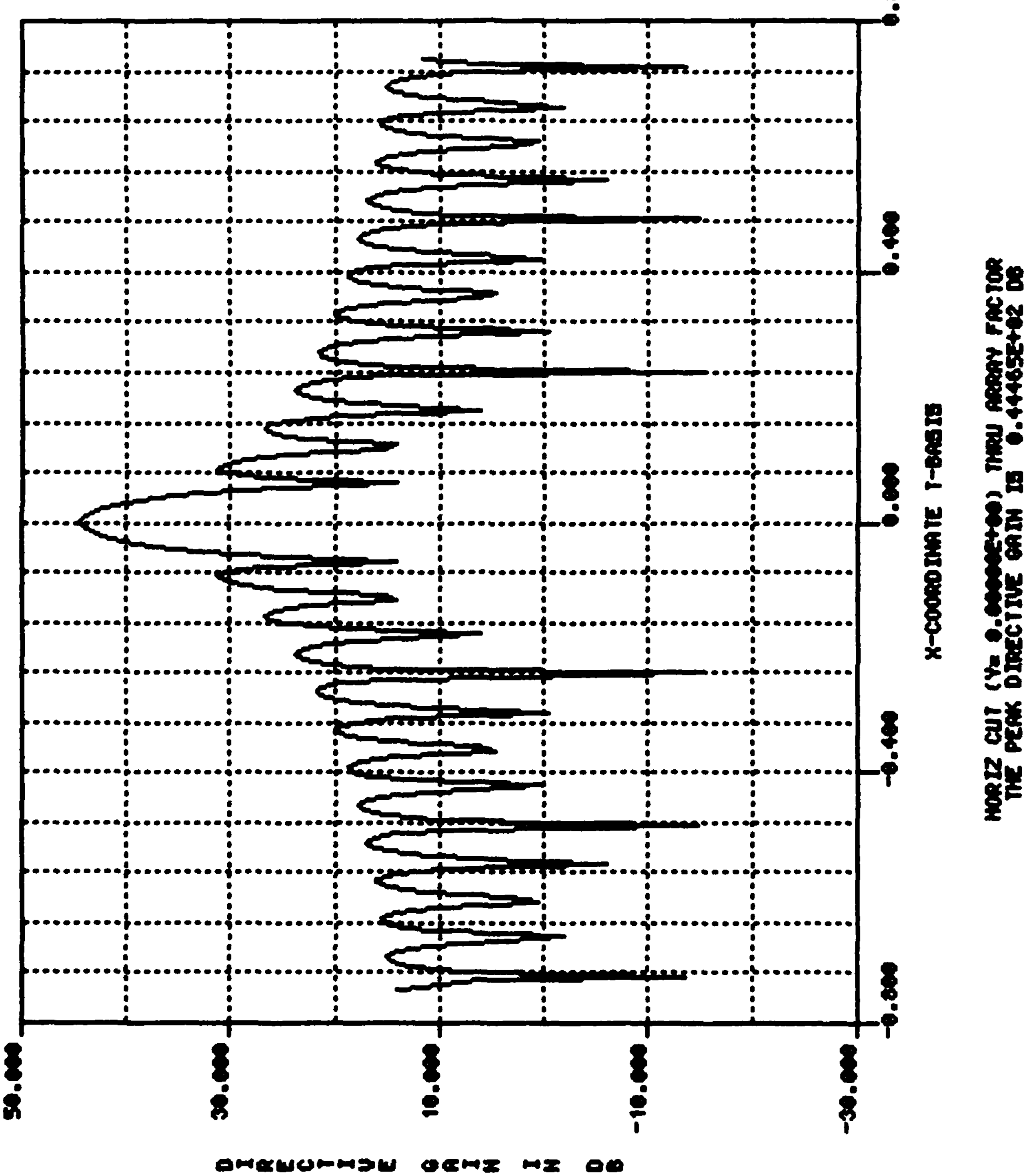
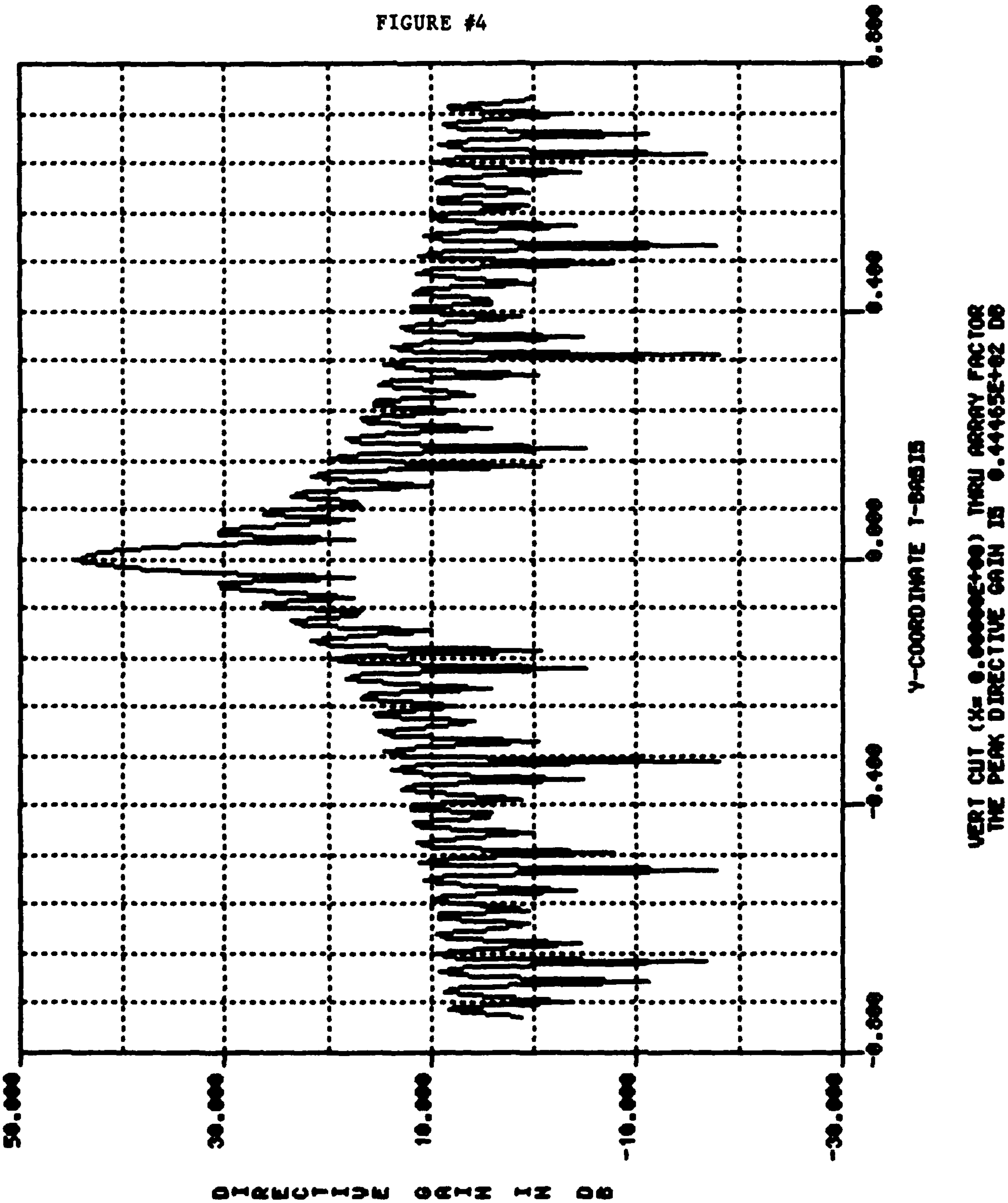

50.000
30.000
10.000
-10.000
-30.000
-0.800
-0.400
0.000
0.400
0.800
X-COORDINATE T-BASIS
HORIZ CUT (Y= 0.00000E+00) THRU ARRAY FACTOR
THE PEAK DIRECTIVE GAIN IS 0.44465E+02 DB

FIGURE #4


50.000
30.000
10.000
-10.000
-30.000
0.800
0.400
0.000
-0.400
-0.800
Y-COORDINATE T-BASIS
VERT CUT (X= 0.0000E+00) THRU ARRAY FACTOR
THE PEAK DIRECTIVE GAIN IS 0.44465E+02 DB

TEST CASE #2

I. PURPOSE

The purpose of this test case is to show the aperture radiation pattern and far-field pattern for an ideal simulation with cosine to a power on a pedestal weighting. Additional parameters for this case are the height of the pedestal, specified to be 0.5, and the power of the function, which is cubed.

II. SYSTEM DESCRIPTION

Frequency:	1.0 GHz
Feed:	Ideal Space Feed
Dimensions:	Height: 10.0 meters
	Width: 5.0 meters
Elements:	28 Bit Phase Shifters
	Isotropic Radiators
Element Spacing:	0.15 meters apart
	Rectangular Lattice

III. WEIGHTING FUNCTION EQUATION

$w(t) = 0.54 + 0.46 \cos 2\pi t/\tau$ for $t <= \tau/2$

$w(t) = 0$ elsewhere

where t = time

τ = period

IV. RESULT ANALYSIS

With cosine to a power on a pedestal aperture weighting the main lobe had a directive gain of 43.90 decibels. In the horizontal direction the side lobes were 22 decibels down, and the deepest null was 56 decibels long. The width of the main lobe was 2.87 degrees. The deepest null on the vertical cut was 32 decibels, while the main lobe was 1.15 degrees wide, and the first side lobes were 20 decibels down. The main lobe measurements were made three decibels down from the top of the lobe.

V. SIMULATION RUN FILE

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SIMSYS
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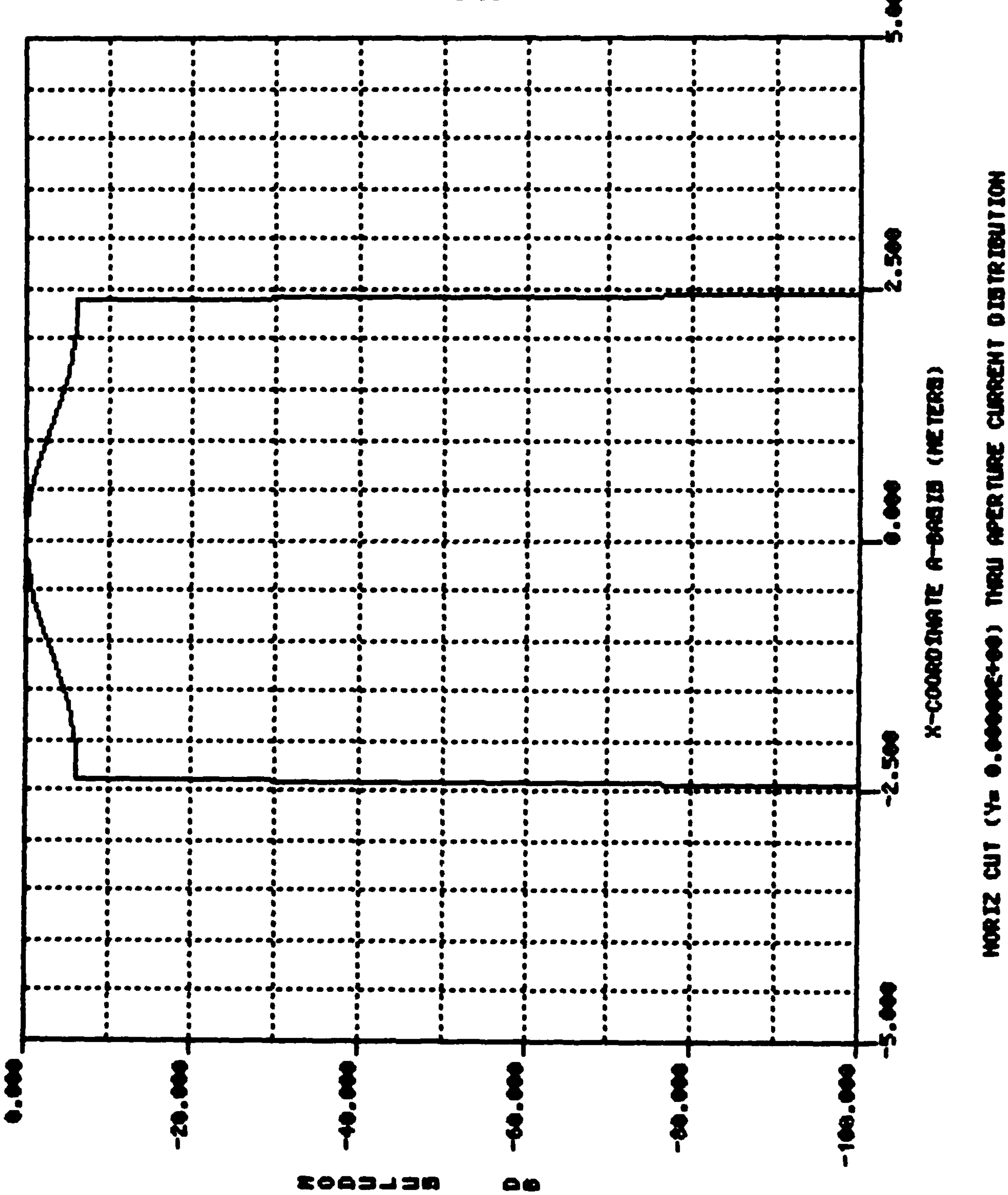
$
LATTICE
ILTYPE=             1, COLSPC=   1.5000E-01, ROWSPC=   1.5000E-01,
$
RSHAPE
XWIDTH=   5.0000E+00, YHIGH  =   1.0000E+01, WTXRAD=   2.4750E+00, WTYRAD=   5.0250E+00,
$
WITSYS
IWTFLG=             1,
$
WTPED  =  5.0000E-01, NWTPOW=              3,
$
SPAFED
XNFEDA=   0.0000E+00, YNFEDA=   0.0000E+00, ZNFEDA=   1.0000E+01, XAFEDA=   0.0000E+00,
YAFEDA=   0.0000E+00, ZAFEDA=   1.0000E+01,
$
PLARY
NO
IBSFLG=             0, XBEAMT=   0.0000E+00, YBEAMT=   0.0000E+00, NBITS  =            28,
LSBRND=             0, IROFF  =              1, ITAPER=              1, DENMAX=   1.0000E+00,
IQ4    =            2,
$
XFORM
NO
YES
N2     =            8, TXCENT=   0.0000E+00, TYCENT=   0.0000E+00, TXSPAN=   1.5000E+00,
TYSPAN=   1.5000E+00,
$
TCS
IGRDF  =           -1, IBAUD  =          9600, ICAPLB=              1,
$
CLOSER
```

VI. OUTPUT DATA

A. PATCUT was used to plot the radiation distribution pattern on the aperture that is seen in figure one (1). Only the horizontal cut is shown since the overall shape of the horizontal and vertical cuts is the same. This command was also used to generate the horizontal and vertical cuts of the far-field radiation pattern seen in figures three (3) and four (4) respectively.

B. PLOT3D was used to plot the three dimensional graph of the far-field radiation pattern that is seen in figure two (2).

FIGURE #1


5.000
2.500
0.000
-2.500
-5.000
0.000
-20.000
-40.000
-60.000
-80.000
-100.000
X-COORDINATE A-BASIS (METERS)
HORIZ CUT (Y= 0.0000E+00) THRU APERTURE CURRENT DISTRIBUTION

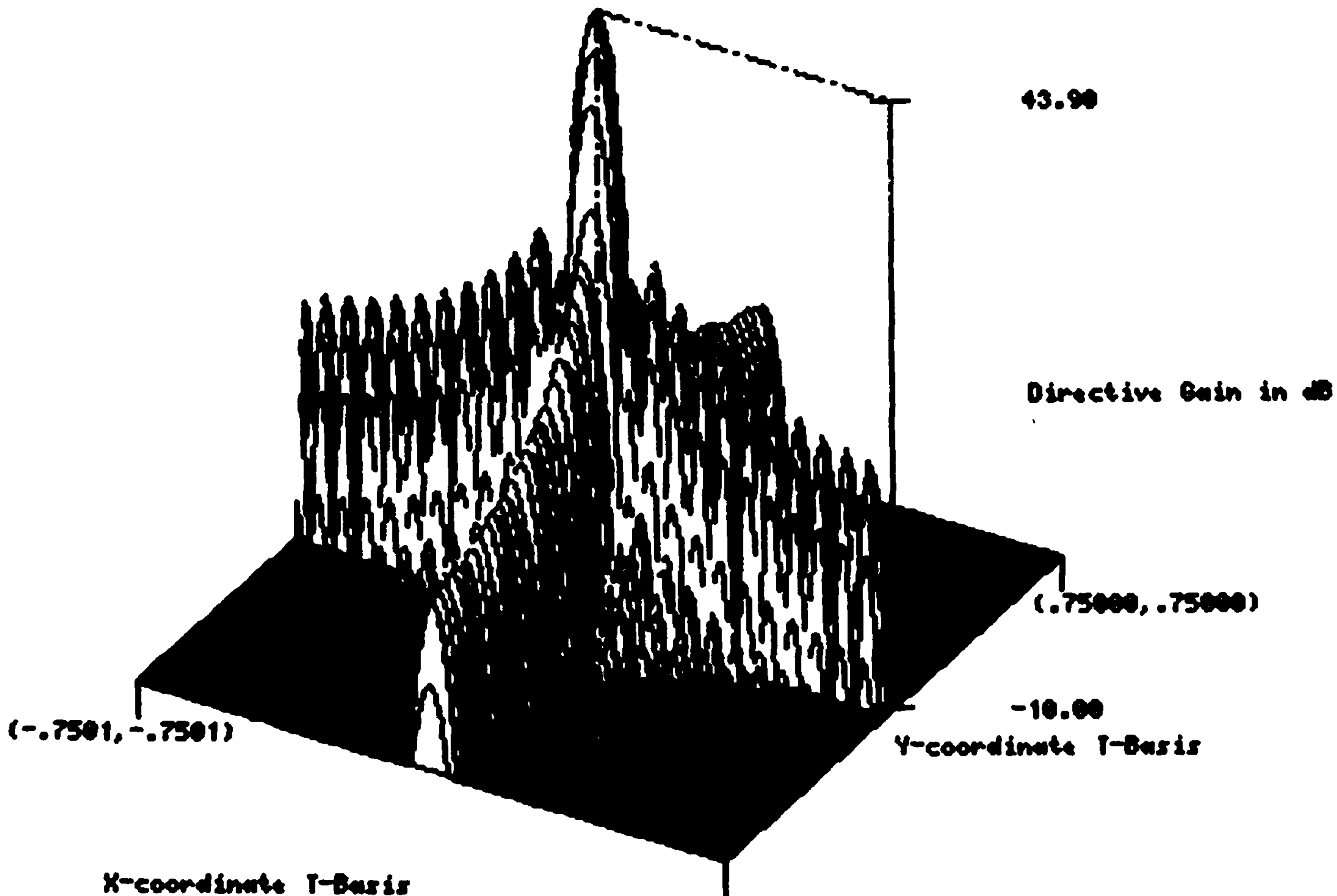


FIGURE #2

Surface Diagram of the Array Factor

THE PEAK DIRECTIVE GAIN IS 43.902DB

FIGURE #3

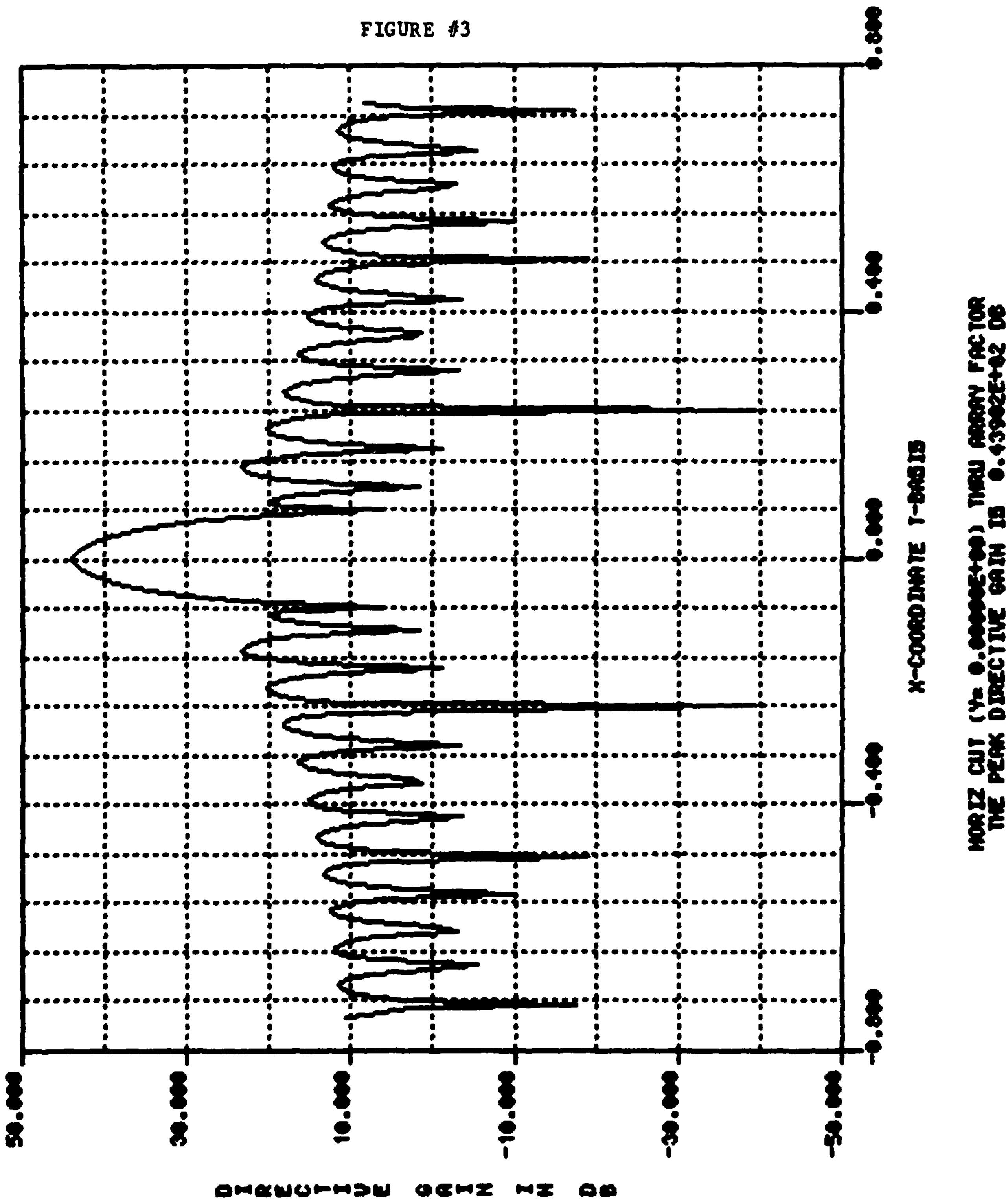
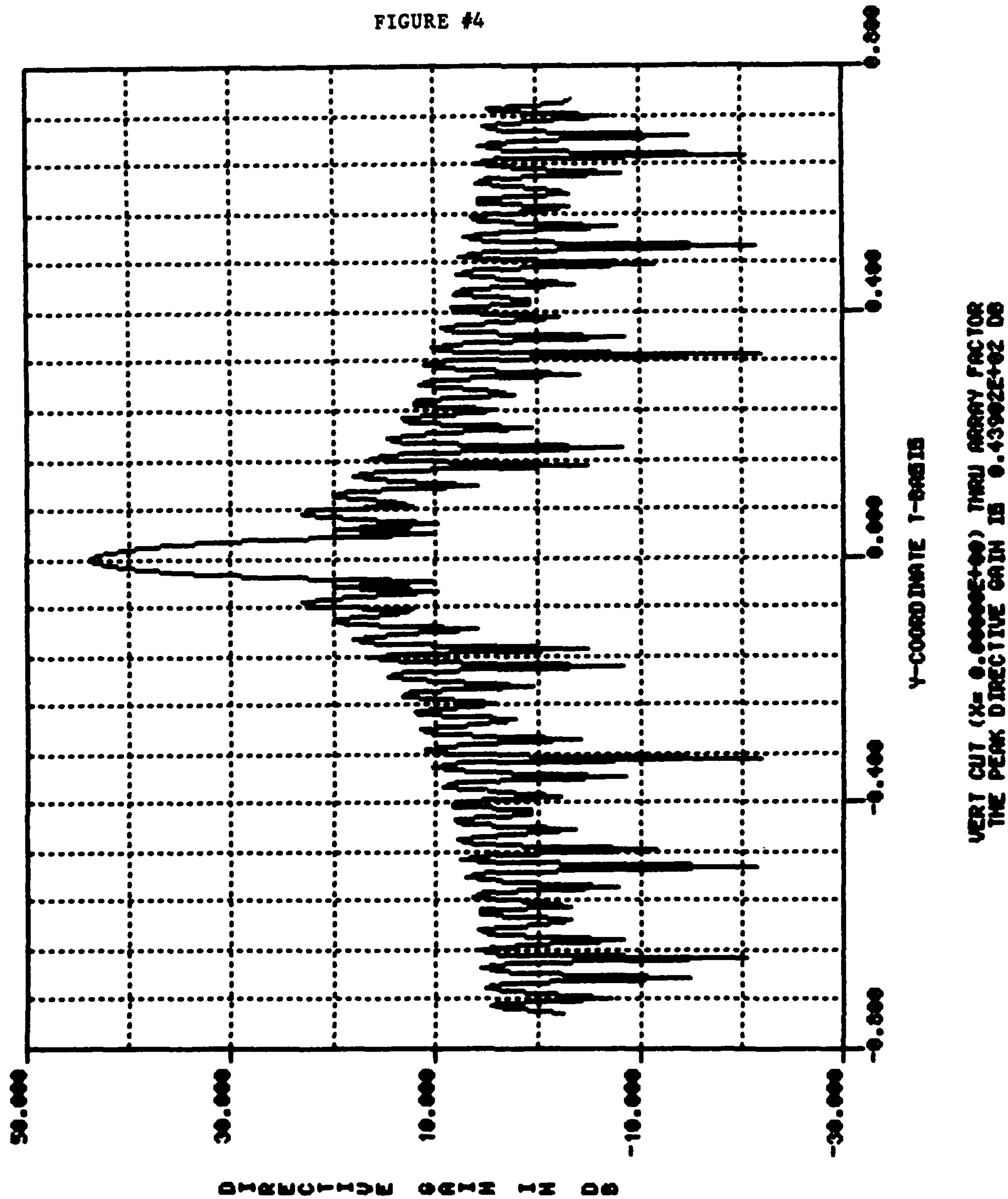

50.000
30.000
10.000
-10.000
-30.000
-50.000
-0.800
-0.400
0.000
0.400
0.800
X-COORDINATE T-BASIS
HORIZ CUT (Y= 0.0000E+00) THRU ARRAY FACTOR
THE PEAK DIRECTIVE GAIN IS 0.4390E+02 DB

FIGURE #4


0.800
0.400
0.000
-0.400
-0.800
50.000
30.000
10.000
-10.000
-30.000
DIRECTIVE GAIN IN DB
Y-COORDINATE T-BASIS
VERT CUT (X= 0.0000E+00) THRU ARRAY FACTOR
THE PEAK DIRECTIVE GAIN IS 0.4390E+02 DB

TEST CASE #3

I. PURPOSE

The purpose of this test case is to show the aperture radiation pattern and far-field pattern for an ideal simulation with Blackman weighting.

II. SYSTEM DESCRIPTION

Frequency:	1.0 GHz
Feed:	Ideal Space Feed
Dimensions:	Height: 10.0 meters
	Width: 5.0 meters
Elements:	28 Bit Phase Shifters
	Isotropic Radiators
Element Spacing:	0.15 meters apart
	Rectangular Lattice

III. WEIGHTING FUNCTION EQUATION

$w(t) = 0.42 + 0.5 \cos 2\pi t/\tau + 0.08 \cos 4\pi t/\tau$ for $t <= \tau/2$

where t = time

τ = period

IV. RESULT ANALYSIS

With Blackman aperture weighting the main lobe had a directive gain of 39.69 decibels. In the horizontal direction the side lobes were 58 decibels down and the deepest null 27 decibels long. The width of the main lobe was 5.45 degrees. The deepest null in the vertical direction was 22 decibels, while the main lobe was 2.30 degrees wide and the first side lobes were 59 decibels down. The main lobe measurements were made three decibels down from the top of the lobe.

V. SIMULATION RUN FILE

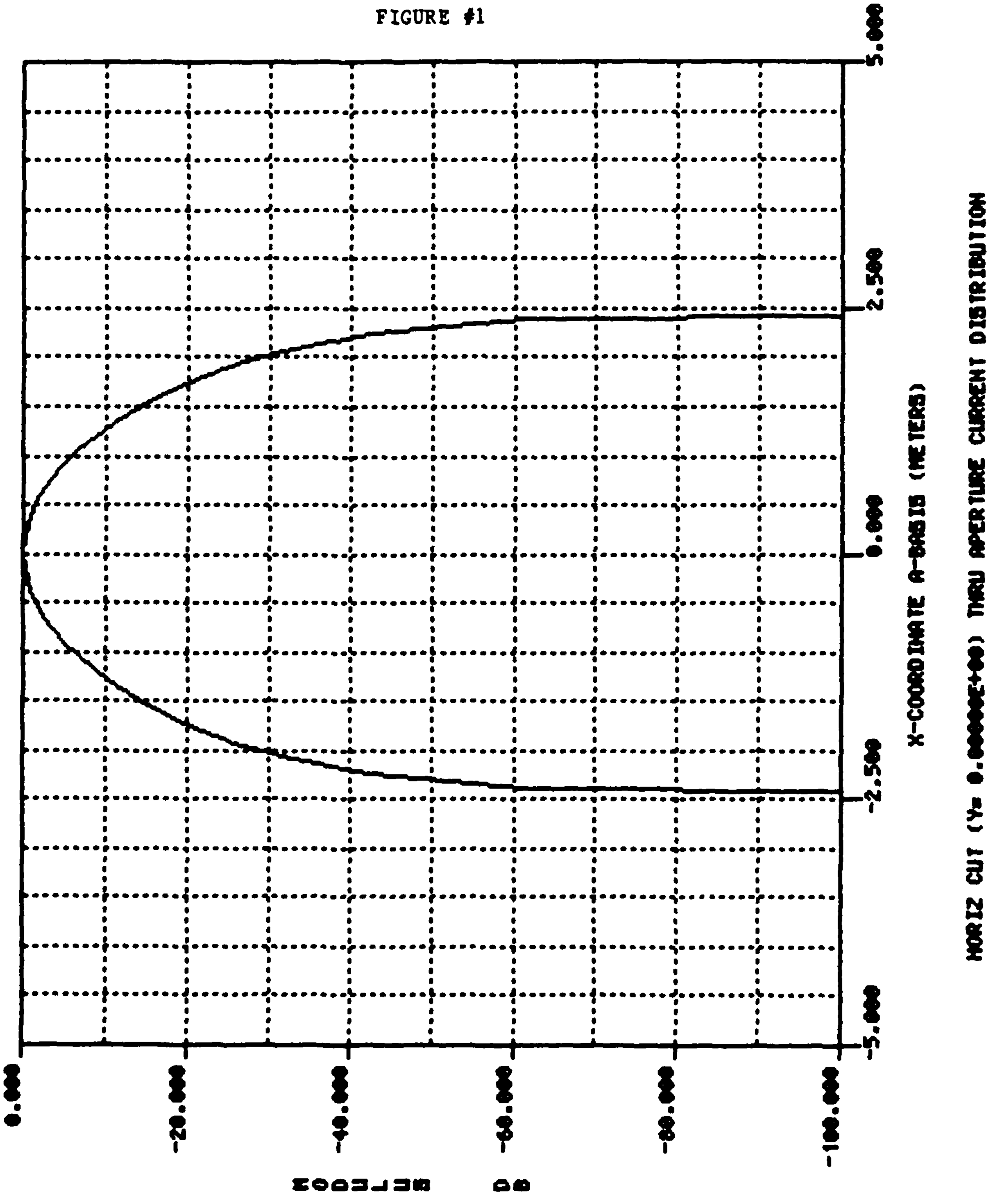
```
SIMSYS
FINST =  1.0000E+00,FOPER =  1.0000E+00,
$
LATTICE
ILTYPE=          1,COLSPC=  1.5000E-01,ROWSPC=  1.5000E-01,
$
RSHAPE
XWIDTH=  5.0000E+00,YHIGH =  1.0000E+01,WTXRAD=  2.4750E+00,WTYRAD=  5.0250E+00,
$
WITSYS
IWTFLG=          2,
$
SPAFED
XNFEDA=  0.0000E+00,YNFEDA=  0.0000E+00,ZNFEDA=  1.0000E+01,XAFEDA=  0.0000E+00,
YAFEDA=  0.0000E+00,ZAFEDA=  1.0000E+01,
$
PLARY
NO
IBSFLG=          0,XBEAMT=  0.0000E+00,YBEAMT=  0.0000E+00,NBITS =          28,
LSBRND=          0,IROFF =           1,ITAPER=           1,DENMAX=  1.0000E+00,
IQ4   =          2,
$
XFORM
NO
YES
N2    =          8,TXCENT=  0.0000E+00,TYCENT=  0.0000E+00,TXSPAN=  1.5000E+00,
TYSPAN=  1.5000E+00,
$
TCS
IGRDF =         -1,IBAUD =        9600,ICAPLB=           1,
$
CLOSER
```

VI. OUTPUT DATA

A. PATCUT was used to plot the radiation distribution pattern on the aperture that is seen in figure one (1). Only the horizontal cut is shown since the overall shape of the horizontal and vertical cuts is the same. This command was also used to generate the horizontal and vertical cuts of the far-field radiation pattern seen in figures three (3) and four (4) respectively.

B. PLOT3D was used to plot the three dimensional graph of the far-field radiation pattern that is seen in figure two (2).

FIGURE #1


5.000
2.500
0.000
-2.500
-5.000
0.000
-20.000
-40.000
-60.000
-80.000
-100.000
X-COORDINATE A-BASIS (METERS)
HORIZ CUT (Y= 0.00000E+00) THRU APERTURE CURRENT DISTRIBUTION
DB

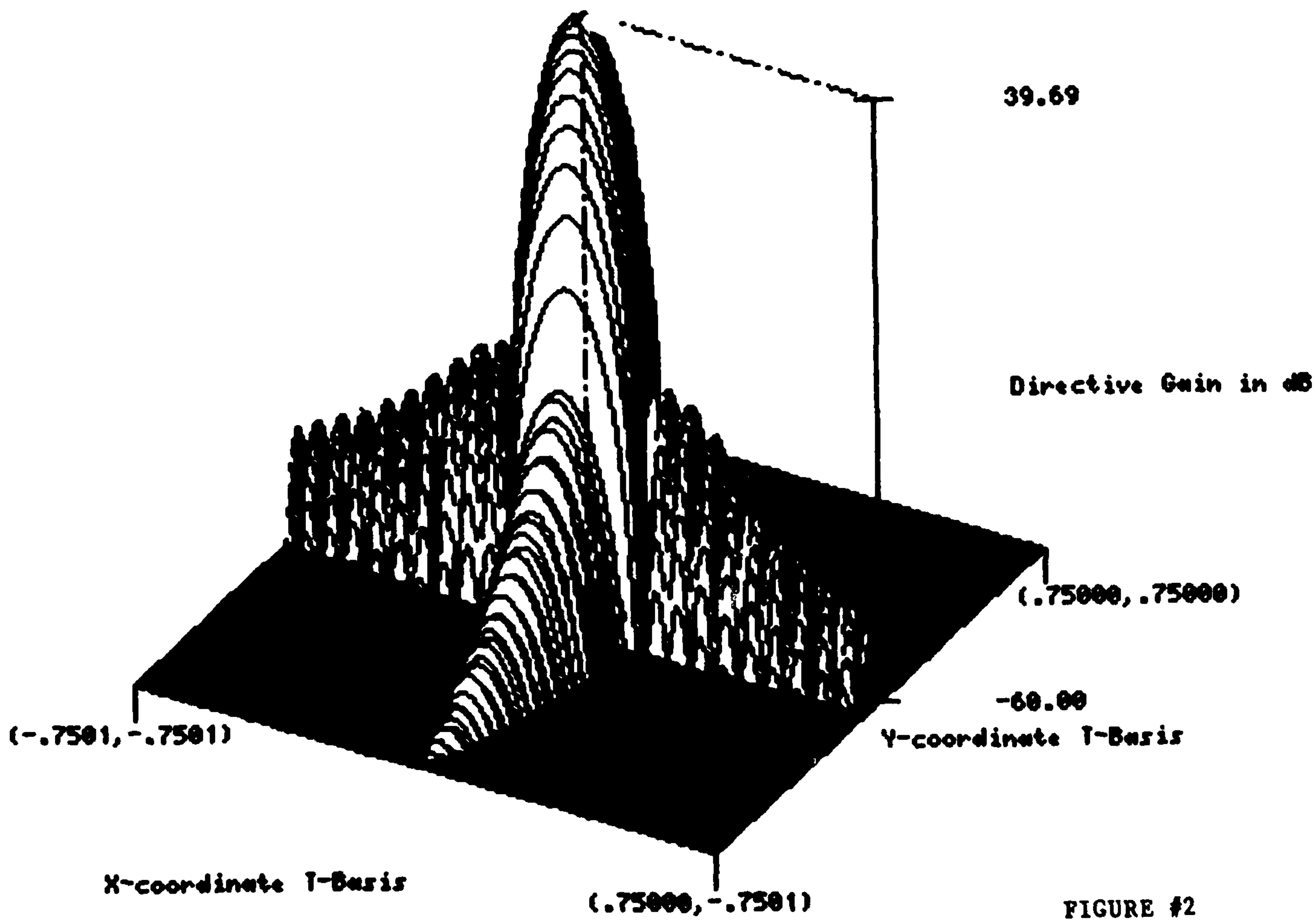
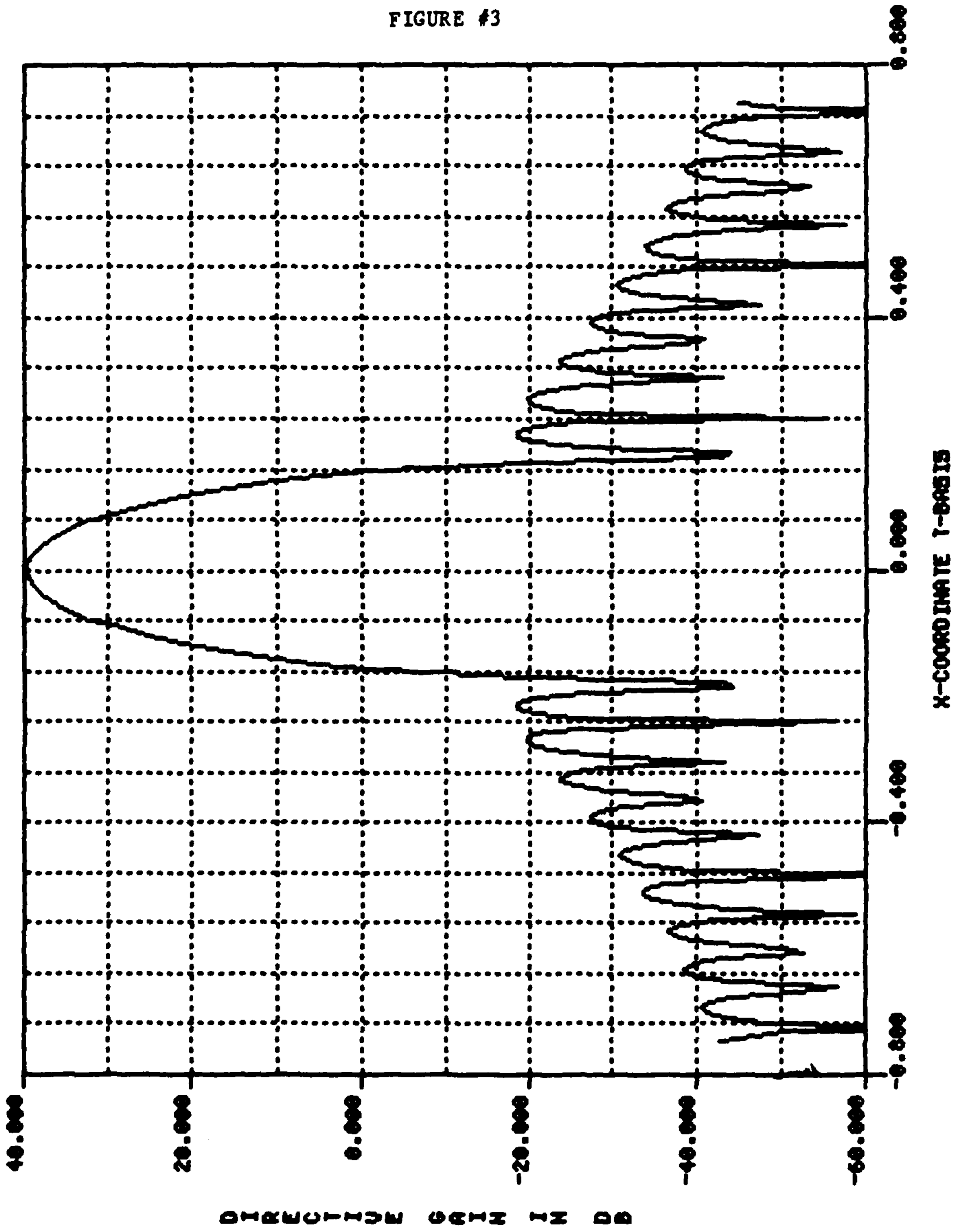


FIGURE #2

Surface Diagram of the Array Factor

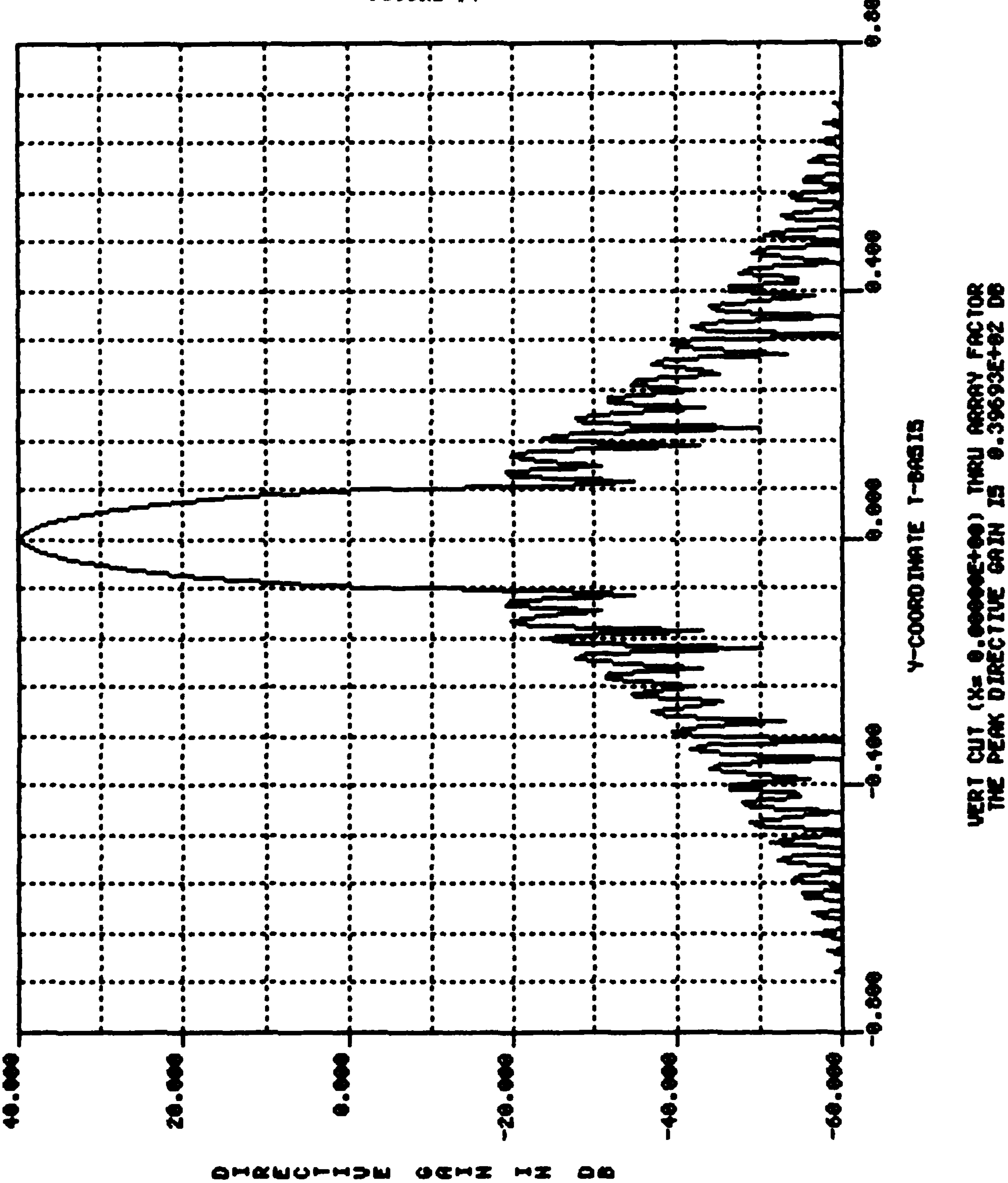
THE PEAK DIRECTIVE GAIN IS 39.693DB

FIGURE #3



HORIZ CUT (Y= 0.00000E+00) THRU ARRAY FACTOR
THE PEAK DIRECTIVE GAIN IS 0.39693E+02 DB

FIGURE #4


VERT CUT (X= 0.00000E+00) THRU ARRAY FACTOR
THE PEAK DIRECTIVE GAIN IS 0.39693E+02 DB
Y-COORDINATE T-BASIS
DIRECTIVE GAIN IN DB
40.000
20.000
0.000
-20.000
-40.000
-60.000
0.800
0.400
0.000
-0.400
-0.800

TEST CASE #4

I. PURPOSE

The purpose of this test case is to show the aperture radiation pattern and far-field pattern for an ideal simulation with Kaiser weighting. The additional parameter for this test case was the Kaiser variable which controls the tradeoff between the main lobe width and the side lobe amplitude. This variable was set at 6.5.

II. SYSTEM DESCRIPTIONS

Frequency:	1.0 GHz
Feed:	Ideal Space Feed
Dimensions:	Height: 10.0 meters
	Width: 5.0 meters
Elements:	28 Bit Phase Shifters
	Isotropic Radiators
Element Spacing:	0.15 meters apart
	Rectangular Lattice

III. WEIGHTING FUNCTION EQUATION

$w(t) = I_0[\theta\sqrt{1-(2t/\tau^2)}] \,/\, I_0(\theta)$ for $t <= \tau/2$

where I_0 = modified Bessel function of the first kind and zeroth order

θ = parameter

t = time

τ = period

IV. RESULT ANALYSIS

With Kaiser aperture weighting the main lobe had a directive gain of 40.81 decibels. In the horizontal direction the side lobes were 47 decibels down and the deepest null was 31 decibel long. The width of the main lobe was 4.30 degrees. The deepest null in the vertical direction was 39 decibels, while the main lobe was 2.30 degrees wide and the first side lobes were 51 decibels down. The main lobe measurements were made three decibels down from the top of the lobe.

V. SIMULATION RUN FILE

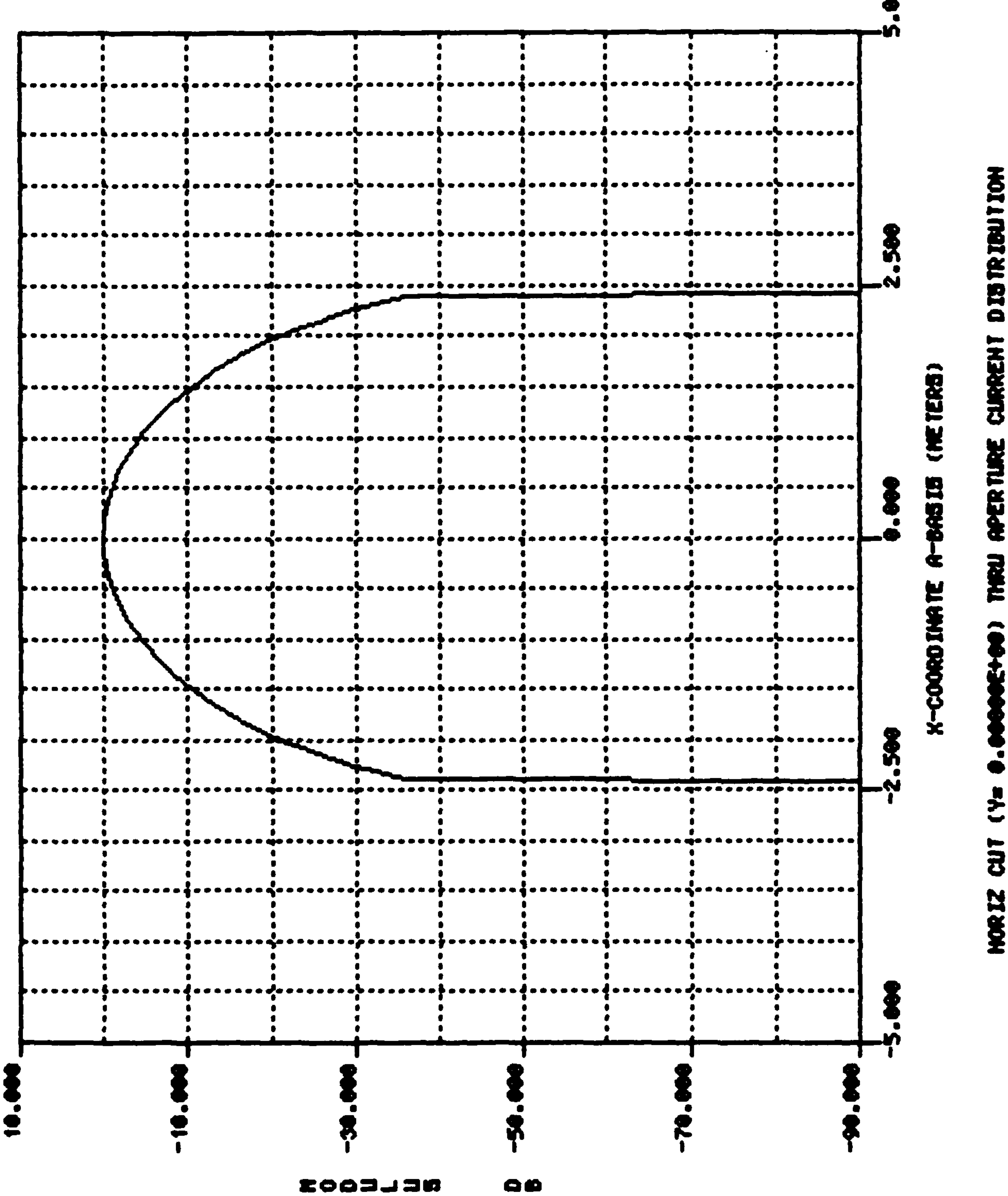
```
SIMSYS
FINST =  1.0000E+00,FOPER =  1.0000E+00,
$
LATTICE
ILTYPE=           1,COLSPC=  1.5000E-01,ROWSPC=  1.5000E-01,
$
RSHAPE
XWIDTH=  5.0000E+00,YHIGH =  1.0000E+01,WTXRAD=  2.4750E+00,WTYRAD=  5.0250E+00,
$
WITSYS
IWTFLG=           3,
$
WKASIR=  6.5000E+00,
$
SPAFED
XNFEDA=  0.0000E+00,YNFEDA=  0.0000E+00,ZNFEDA=  1.0000E+01,XAFEDA=  0.0000E+00,
YAFEDA=  0.0000E+00,ZAFEDA=  1.0000E+01,
$
PLARY
NO
IBSFLG=           0,XBEAMT=  0.0000E+00,YBEAMT=  0.0000E+00,NSITS =          28,
LSBRND=           0,IROFF =           1,ITAPER=           1,DENMAX=  1.0000E+00,
IG4   =           2,
$
XFORM
NO
YES
N2    =           8,TXCENT=  0.0000E+00,TYCENT=  0.0000E+00,TXSPAN=  1.5000E+00,
TYSPAN=  1.5000E+00,
$
TCS
IGRDF =          -1,IBAUD =        9600,ICAPLB=           1,
$
CLOSER
```

VI. OUTPUT DATA

A. PATCUT was used to plot the radiation distribution pattern on the aperture that is seen in figure one (1). Only the horizontal cut is shown since the overall shape of the horizontal and vertical cuts is the same. This command was also used to generate the horizontal and vertical cuts of the far-field radiation pattern seen in figures three (3) and four (4) respectively.

B. PLOT3D was used to plot the three dimensional graph of the far-field radiation pattern that is seen in figure two (2).

FIGURE #1



X-COORDINATE A-BASIS (METERS)
HORIZ CUT (Y= 0.00000E+00) THRU APERTURE CURRENT DISTRIBUTION
5.000
2.500
0.000
-2.500
-5.000
10.000
-10.000
-30.000
-50.000
-70.000
-90.000
DB

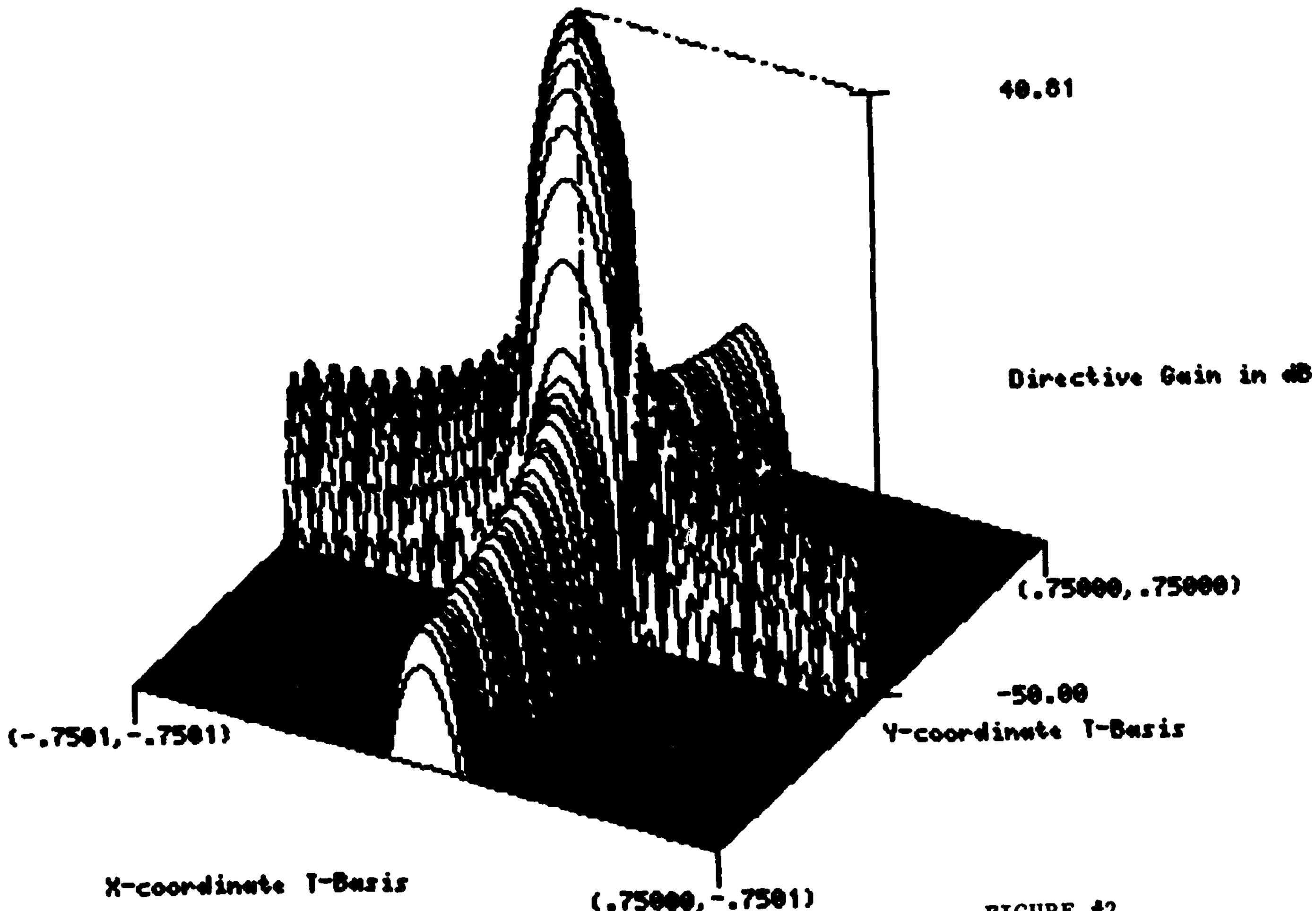
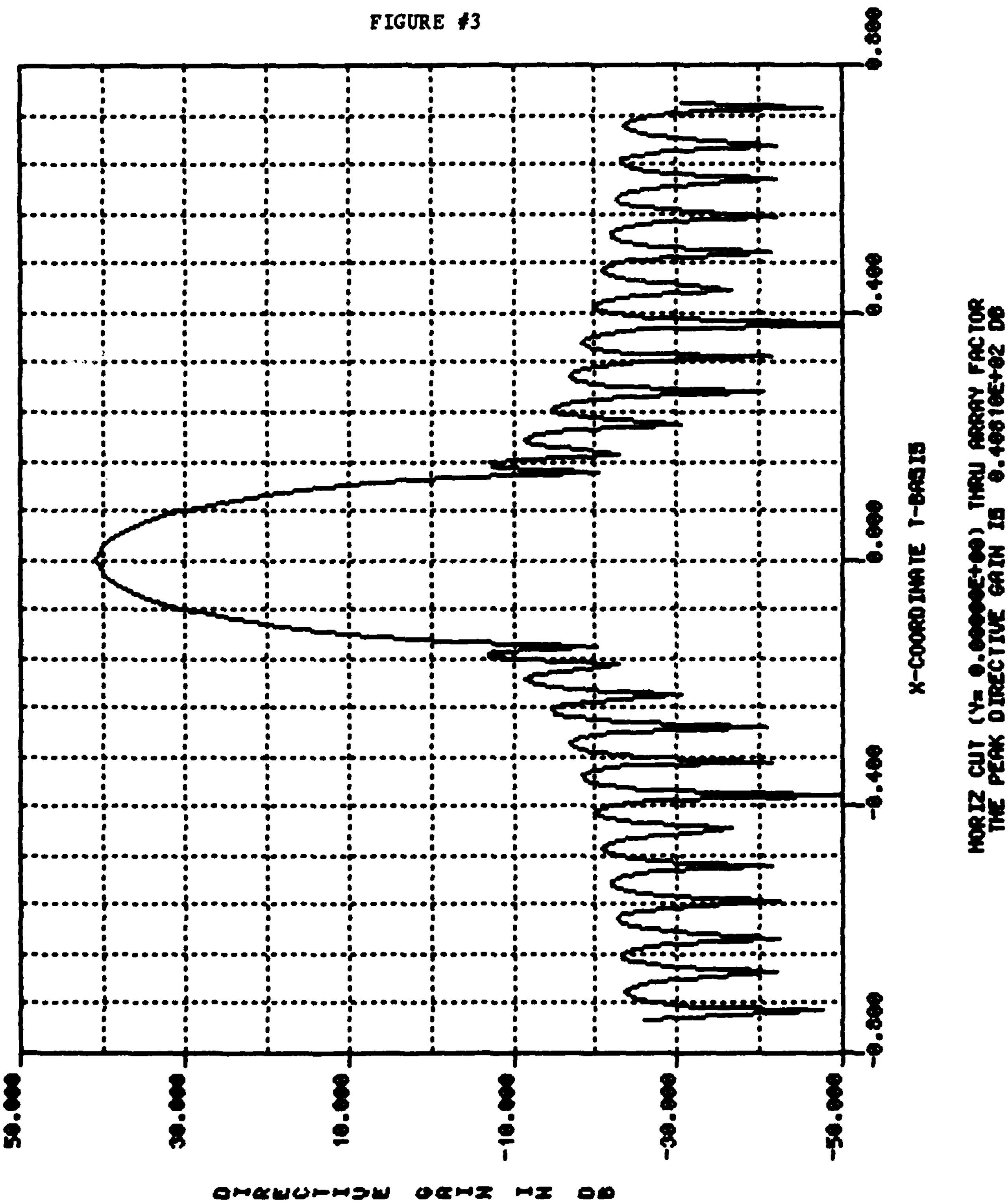


FIGURE #2

Surface Diagram of the Array Factor

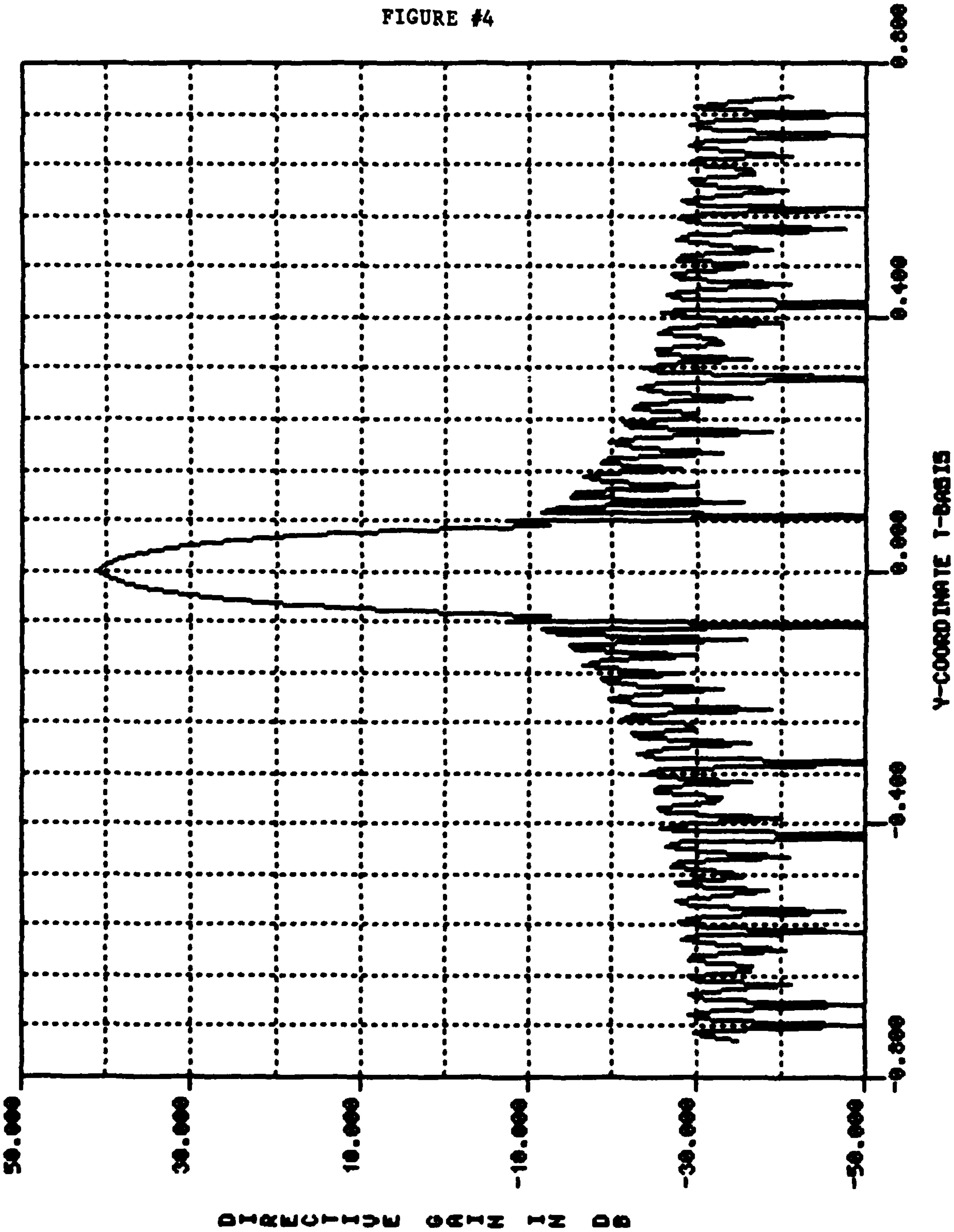
THE PEAK DIRECTIVE GAIN IS 40.810DB

FIGURE #3



50.000
30.000
10.000
-10.000
-30.000
-50.000
-0.800
-0.400
0.000
0.400
0.800
DIRECTIVE GAIN IN DB
X-COORDINATE T-BASIS
HORIZ CUT (Y= 0.00000E+00) THRU ARRAY FACTOR
THE PEAK DIRECTIVE GAIN IS 0.40810E+02 DB

FIGURE #4



VERT CUT (X= 0.00000E+00) THRU ARRAY FACTOR
THE PEAK DIRECTIVE GAIN IS 0.40810E+02 DB

TEST CASE #5

I. PURPOSE

The purpose of this test case is to show the aperture radiation pattern and far-field pattern for an ideal simulation with triangular weighting.

II. SYSTEM DESCRIPTION

Frequency:	1.0 GHz
Feed:	Ideal Space Feed
Dimensions:	Height: 10.0 meters
	Width: 5.0 meters
Elements:	28 Bit Phase Shifters
	Isotropic Radiators
Element Spacing:	0.15 meters apart
	Rectangular Lattice

III. WEIGHTING FUNCTION EQUATION

$w(t) = 1 - 2|t|/\tau$ for $|t| \leq \tau/2$

where t = time

τ = period

IV. RESULT ANALYSIS

With triangular aperture weighting the main lobe had a directive gain of 41.94 decibels. In the horizontal direction the side lobes were 27 decibels down and the deepest null was 26 decibels long. The width of the main lobe was 3.73 degrees. The deepest null in the vertical direction was 31 decibels, while the main lobe was 1.72 degrees wide and the first sides lobes were 27 decibels down. The main lobe measurements were made three decibels down from the top of the lobe.

V. SIMULATION RUN FILE

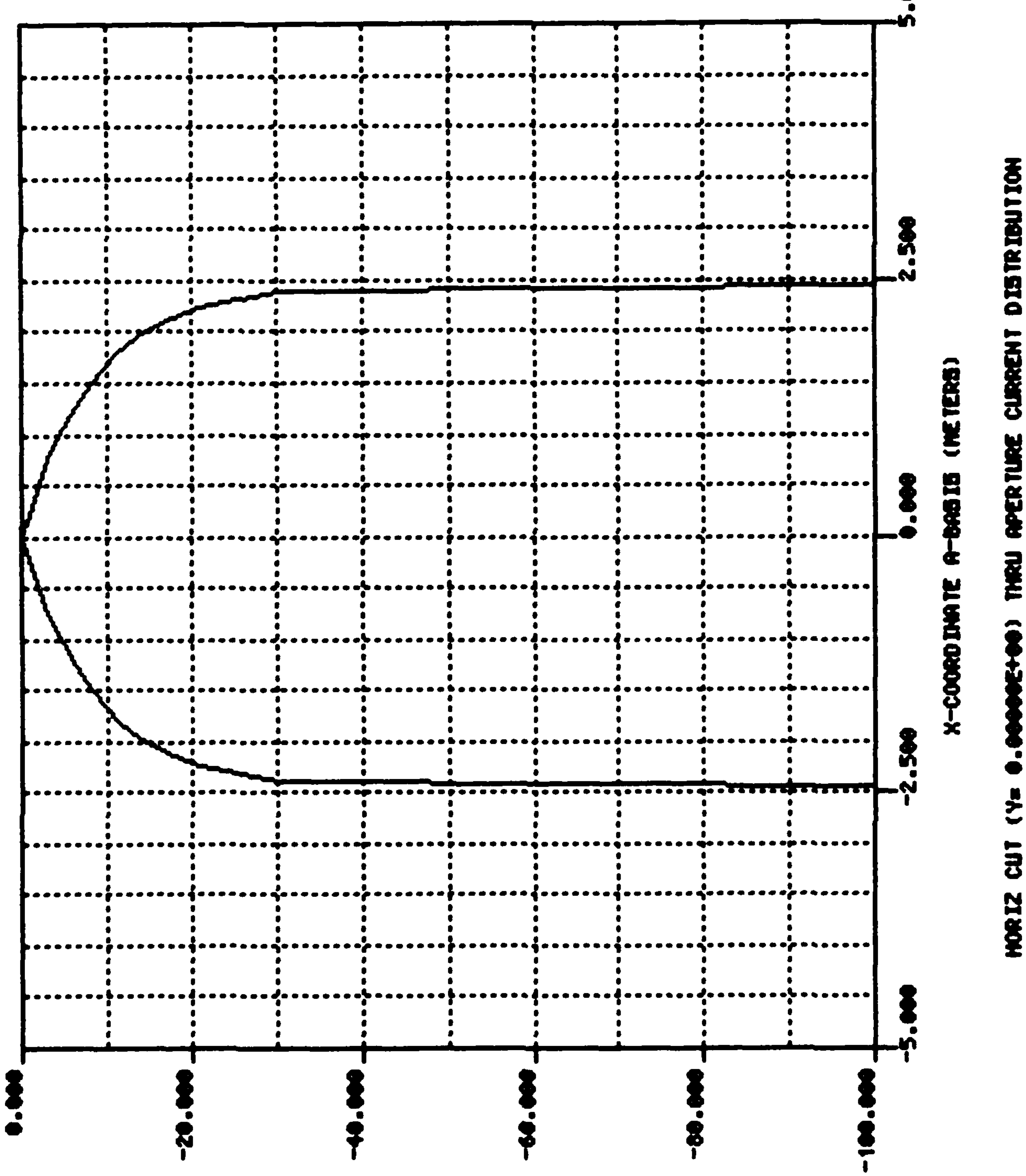
```
SIMSYS
FINST  =   1.0000E+00, FOPER  =   1.0000E+00,
$
LATTICE
ILTYPE=              1, COLSPC=   1.5000E-01, ROWSPC=   1.5000E-01,
$
RSHAPE
XWIDTH=   5.0000E+00, YHIGH  =   1.0000E+01, WTXRAD=   2.4750E+00, WTYRAD=   5.0250E+00,
$
WITSYS
IWTFLG=              4,
$
SPAFED
XNFEDA=   0.0000E+00, YNFEDA=   0.0000E+00, ZNFEDA=   1.0000E+01, XAFEDA=   0.0000E+00,
YAFEDA=   0.0000E+00, ZAFEDA=   1.0000E+01,
$
PLARY
NO
IBSFLG=              0, XBEAMT=   0.0000E+00, YBEAMT=   0.0000E+00, NBITS  =            28,
LSBRND=              0, IROFF  =              1, ITAPER=              1, DENMAX=   1.0000E+00,
IQ4    =             2,
$
XFORM
NO
YES
N2     =             8, TXCENT=   0.0000E+00, TYCENT=   0.0000E+00, TXSPAN=   1.5000E+00,
TYSPAN=   1.5000E+00,
$
TCS
IGRDF  =            -1, IBAUD  =           9600, ICAPLB=              1,
$
CLOSER
```

VI. OUTPUT DATA

A. PATCUT was used to plot the radiation distribution pattern on the aperture that is seen in figure one (1). Only the horizontal cut is shown since the overall shape of the horizontal and vertical cuts is the same. This command was also used to generate the horizontal and vertical cuts of the far-field radiation pattern seen in figures three (3) and four (4) respectively.

B. PLOT3D was used to plot the three dimensional graph of the far-field radiation pattern that is seen in figure two (2).

FIGURE #1



5.000
2.500
0.000
-2.500
-5.000
0.000
-20.000
-40.000
-60.000
-80.000
-100.000
X-COORDINATE A-BASIS (METERS)
HORIZ CUT (Y= 0.0000E+00) THRU APERTURE CURRENT DISTRIBUTION

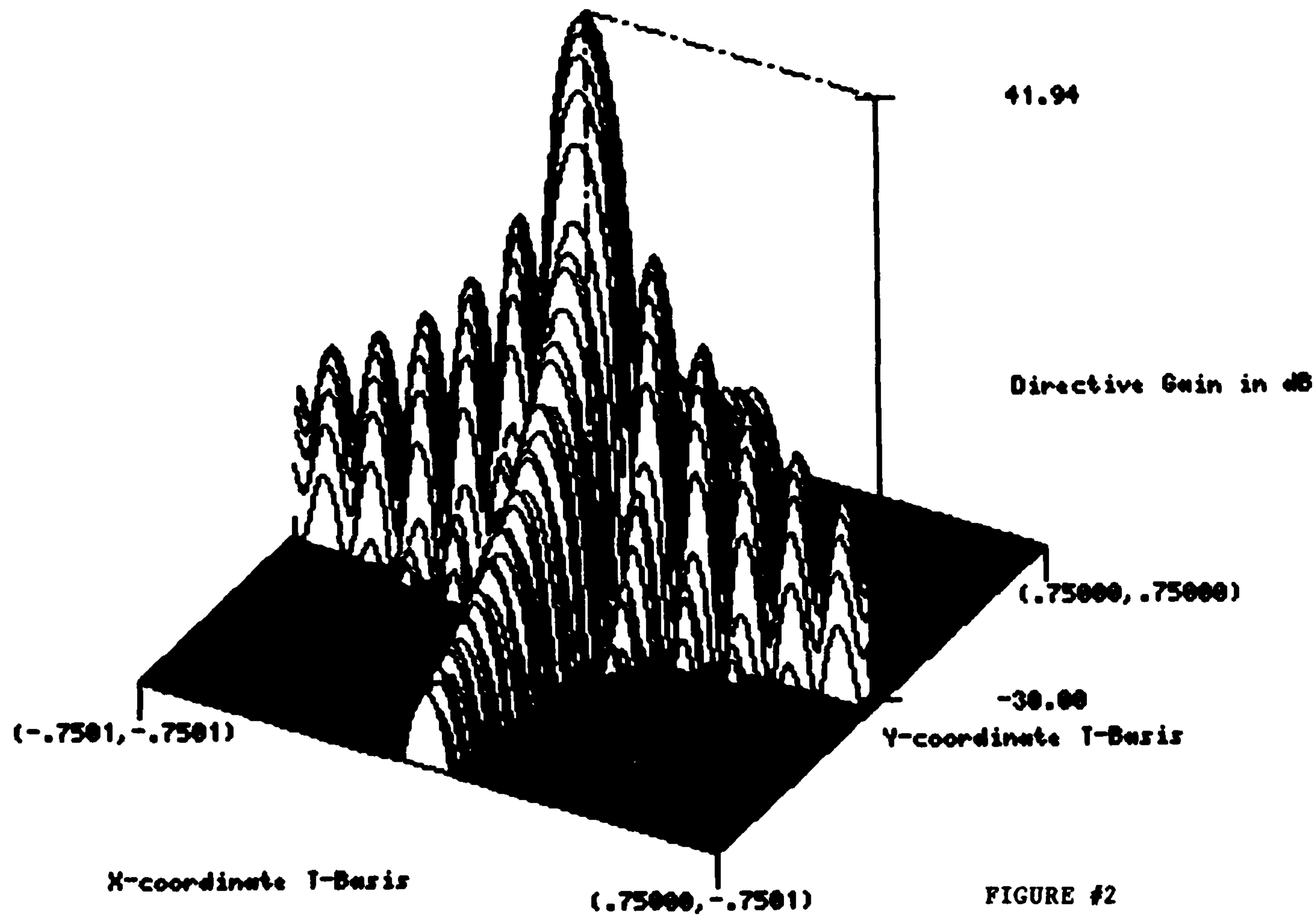


FIGURE #2

Surface Diagram of the Array Factor

THE PEAK DIRECTIVE GAIN IS 41.939DB

FIGURE #3

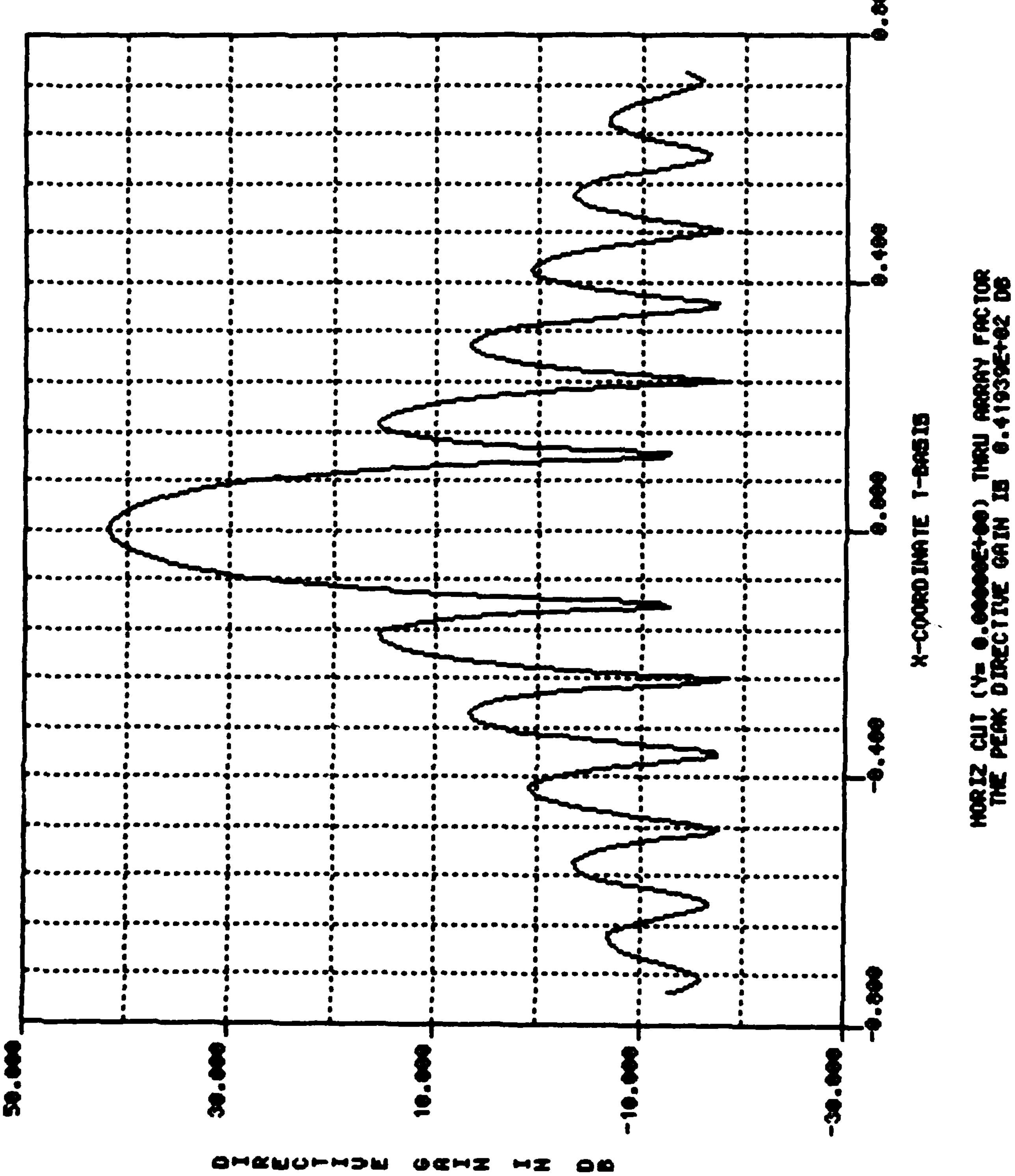
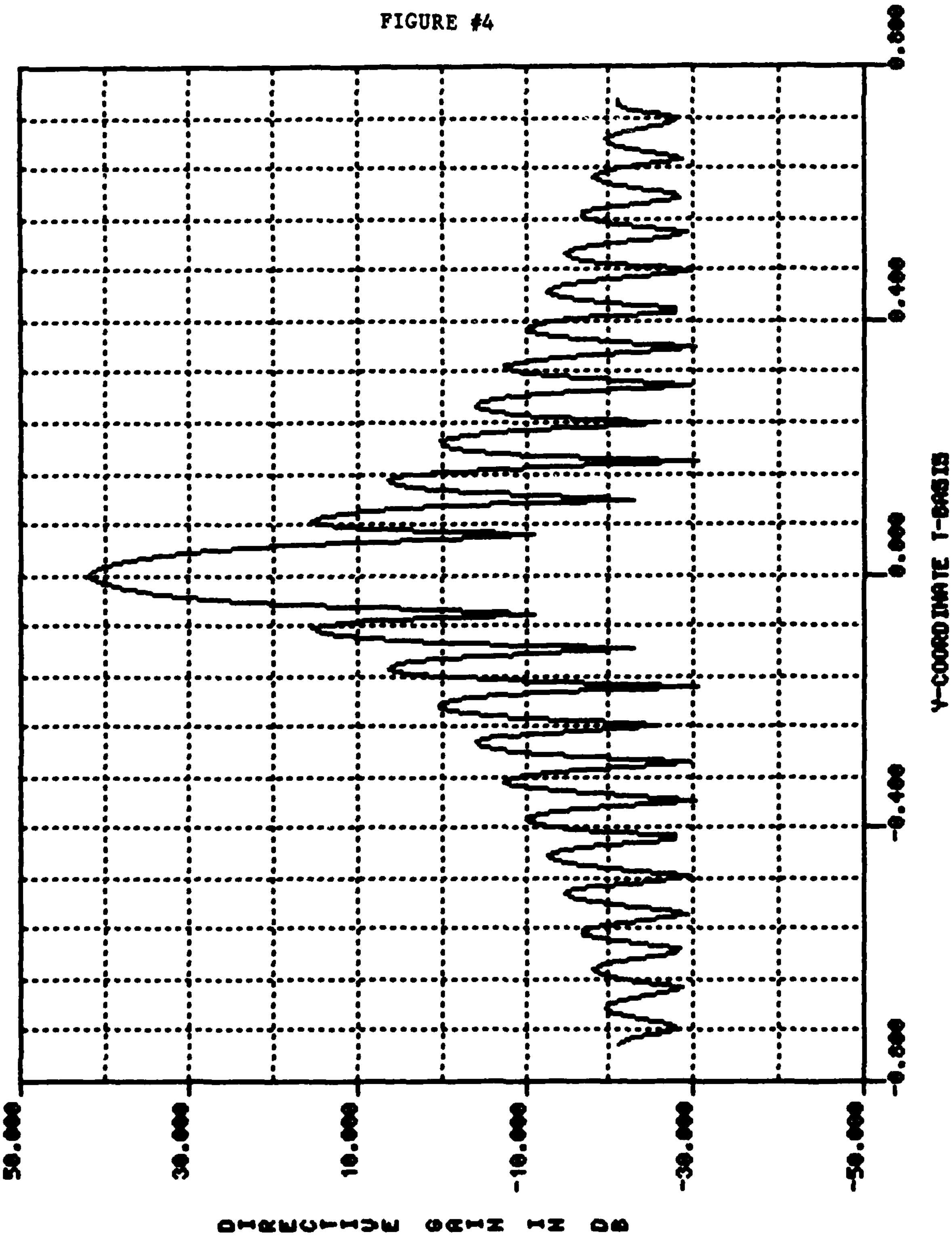

50.000
30.000
10.000
-10.000
-30.000
DIRECTIVE GAIN IN DB
-0.800
-0.400
0.000
0.400
0.800
X-COORDINATE T-BASIS
HORIZ CUT (Y= 0.0000E+00) THRU ARRAY FACTOR
THE PEAK DIRECTIVE GAIN IS 0.41939E+02 DB

FIGURE #4



VERT CUT (X= 0.0000E+00) THRU ARRAY FACTOR
THE PEAK DIRECTIVE GAIN IS 0.41939E+02 DB

TEST CASE #6

I. PURPOSE

The purpose of this test case is to show the aperture radiation pattern and far-field pattern for an ideal simulation with Bessel weighting. Additional parameters for this test case are the maximum amplitude at the center, which is set at 42.0, and the scale factor, specified to be 3.

II. SYSTEM DESCRIPTION

Frequency:	1.0 GHz
Feed:	Ideal Space Feed
Dimensions:	Height: 10.0 meters
	Width: 5.0 meters
Elements:	28 Bit Phase Shifters
	Isotropic Radiators
Element Spacing:	0.15 meters apart
	Rectangular Lattice

III. WEIGHTING FUNCTION EQUATION

$$J_n(x) = 1/n \int_c^{\pi} \cos(x \sin\Theta - n\Theta) d\Theta$$

where n = order

x = argument

θ = angle in degrees

IV. RESULT ANALYSIS

With Bessel aperture weighting the main lobe had a directive gain of 34.45 decibels. Note the two main beams instead of the usual one. In the horizontal direction the side lobes were 15 decibels down and the deepest null was 38 decibels long. The width of the two main lobes and the distance between them was 17.46 degrees. The deepest null in the vertical direction was 37 decibels, while the two main lobes and the distance between them measured 17.46 degrees and the first side lobes were 18 decibels down. The main lobe measurements were made three decibels from the top of the lobe.

V. SIMULATION RUN FILE

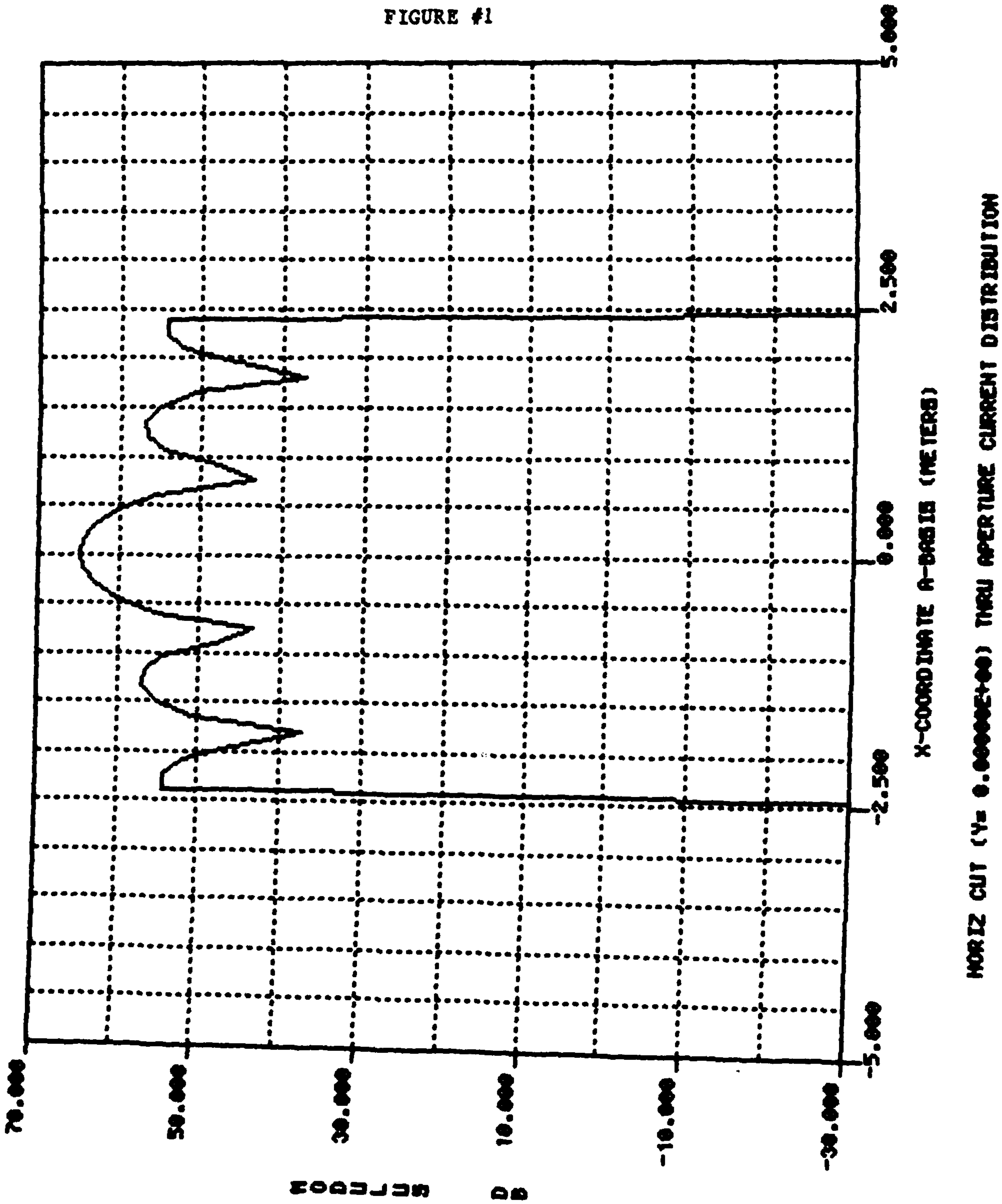
```
SIMSYS
FINST =  1.0000E+00.FOPER =  1.0000E+00,
$
LATTICE
ILTYPE=           1,COLSPC=  1.5000E-01,ROWSPC=  1.5000E-01,
$
RSHAPE
XWIDTH=  5.0000E+00,YHIGH =  1.0000E+01,WTXRAD=  2.4750E+00,WTYRAD=  5.0250E+00,
$
WITSYS
IWTFLG=           6,
$
BESCAL=  4.2000E+01,BESEDG=  3.0000E+00,
$
SPAFED
XNFEDA=  0.0000E+00,YNFEDA=  0.0000E+00,ZNFEDA=  1.0000E+01,XAFEDA=  0.0000E+00,
YAFEDA=  0.0000E+00,ZAFEDA=  1.0000E+01,
$
PLARY
NO
IBSFLG=           0,XBEAMT=  0.0000E+00,YBEAMT=  0.0000E+00,NBITS =          28,
LSBRND=           0,IROFF =           1,ITAPER=           1,DENMAX=  1.0000E+00,
IG4   =           2,
$
XFORM
NO
YES
N2    =           8,TXCENT=  0.0000E+00,TYCENT=  0.0000E+00,TXSPAN=  1.5000E+00,
TYSPAN=  1.5000E+00,
$
TCS
IGRDF =          -1,IBAUD =        9600,ICAPLB=           1,
$
CLOSER
```

VI. OUTPUT DATA

A. PATCUT was used to plot the radiation distribution pattern on the aperture that is seen in figure one (1). Only the horizontal cut is shown since the overall shape of the horizontal and vertical cuts is the same. This command was also used to generate the horizontal and vertical cuts of the far-field radiation pattern seen in figures three (3) and four (4) respectively.

B. PLOT3D was used to plot the three dimensional graph of the far-field radiation pattern that is seen in figure two (2).

FIGURE #1


5.000
2.500
0.000
-2.500
-5.000
70.000
50.000
30.000
10.000
-10.000
-30.000
X-COORDINATE A-BASIS (METERS)
HORIZ CUT (Y= 0.0000E+00) THRU APERTURE CURRENT DISTRIBUTION

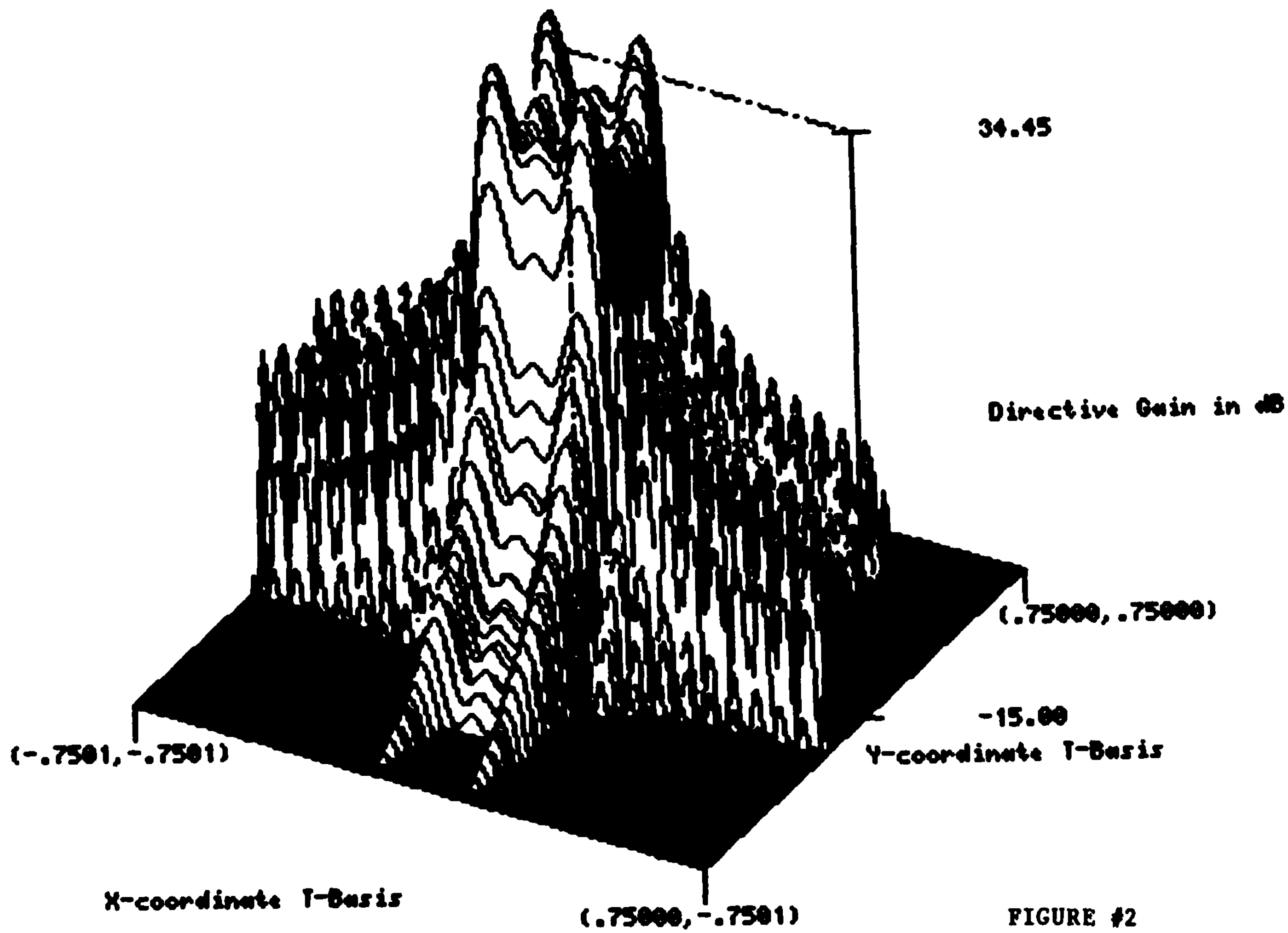


FIGURE #2

Surface Diagram of the Array Factor

THE PEAK DIRECTIVE GAIN IS 34.449DB

FIGURE #3

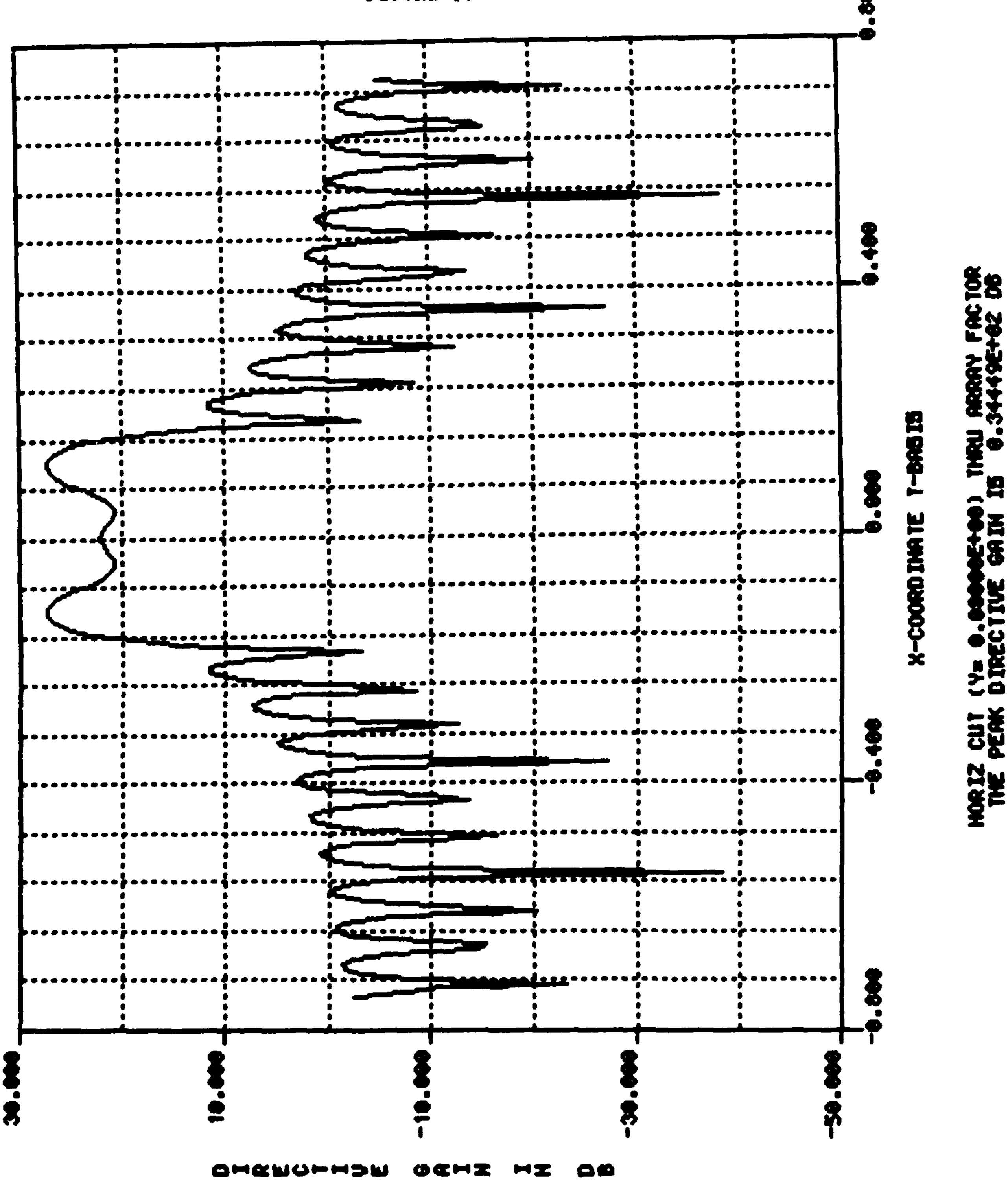
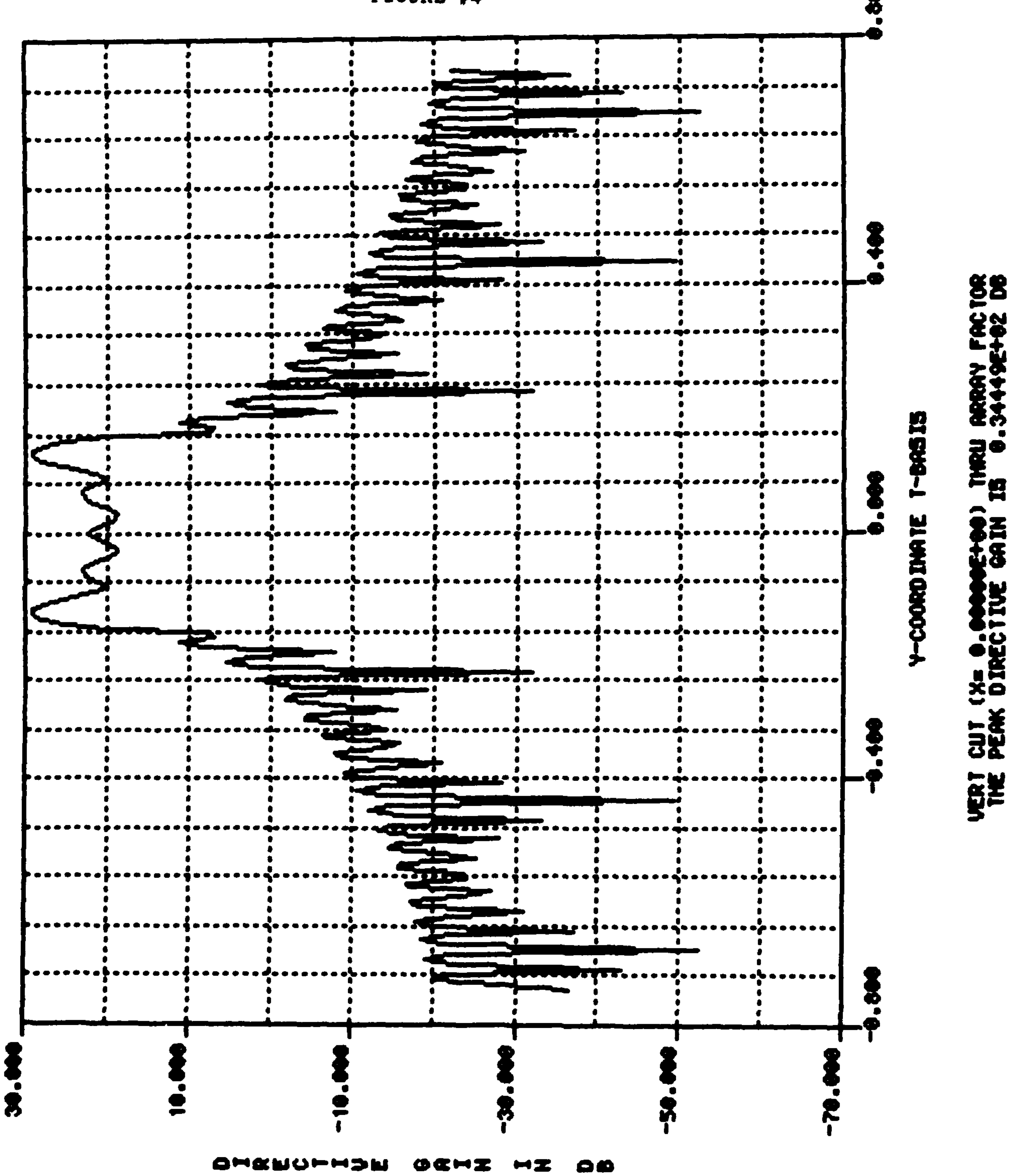

30.000
10.000
-10.000
-30.000
-50.000
DIRECTIVE GAIN IN DB
-0.800
-0.400
0.000
0.400
0.800
X-COORDINATE T-BASIS
HORIZ CUT (Y= 0.00000E+00) THRU ARRAY FACTOR
THE PEAK DIRECTIVE GAIN IS 0.34449E+02 DB

FIGURE #4



30.000
10.000
-10.000
-30.000
-50.000
-70.000
DIRECTIVE GAIN IN DB
-0.800
-0.400
0.000
0.400
0.800
Y-COORDINATE T-BASIS
VERT CUT (X= 0.0000E+00) THRU ARRAY FACTOR
THE PEAK DIRECTIVE GAIN IS 0.34449E+02 DB

TEST CASE #7

I. PURPOSE

The purpose of this test case is to show the aperture radiation pattern and far-field pattern for an ideal simulation with cubic weighting. The additional parameter for this test case is the maximum amplitude at the center, specified to be 50.

II. SYSTEM DESCRIPTION

Frequency:	1.0 GHz
Feed:	Ideal Space Feed
Dimensions:	Height: 10.0 meters
	Width: 5.0 metes
Elements:	28 Bit Phase Shifters
	Isotropic Radiators
Element Spacing:	0.15 meters apart
	Rectangular Lattice

III. WEIGHTING FUNCTION EQUATION

w(t) = CUBK / |(WTRAD/1.73205)(WTRAD/1.73205 - WTRAD)

(WTRAD/1.73205 + WTRAD)|(RAD)(RAD + WTRAD)(RAD - WTRAD)

where CUBK = maximum weighting function amplitude

WTRAD = maximum element radius

RAD = element radial location

IV. RESULT ANALYSIS

With cubic aperture weighting the main lobe had a directive gain of 41.99 decibels. In the horizontal direction the side lobes were 15 decibels down and the deepest null was 90 decibels. The width of the two main lobes and the space between them was 9.21 degrees. The deepest null in the vertical direction was 48 decibels, and there was no discernible main lobe. The main lobe measurements were made three decibels form the top of the lobe.

V. SIMULATION RUN FILE

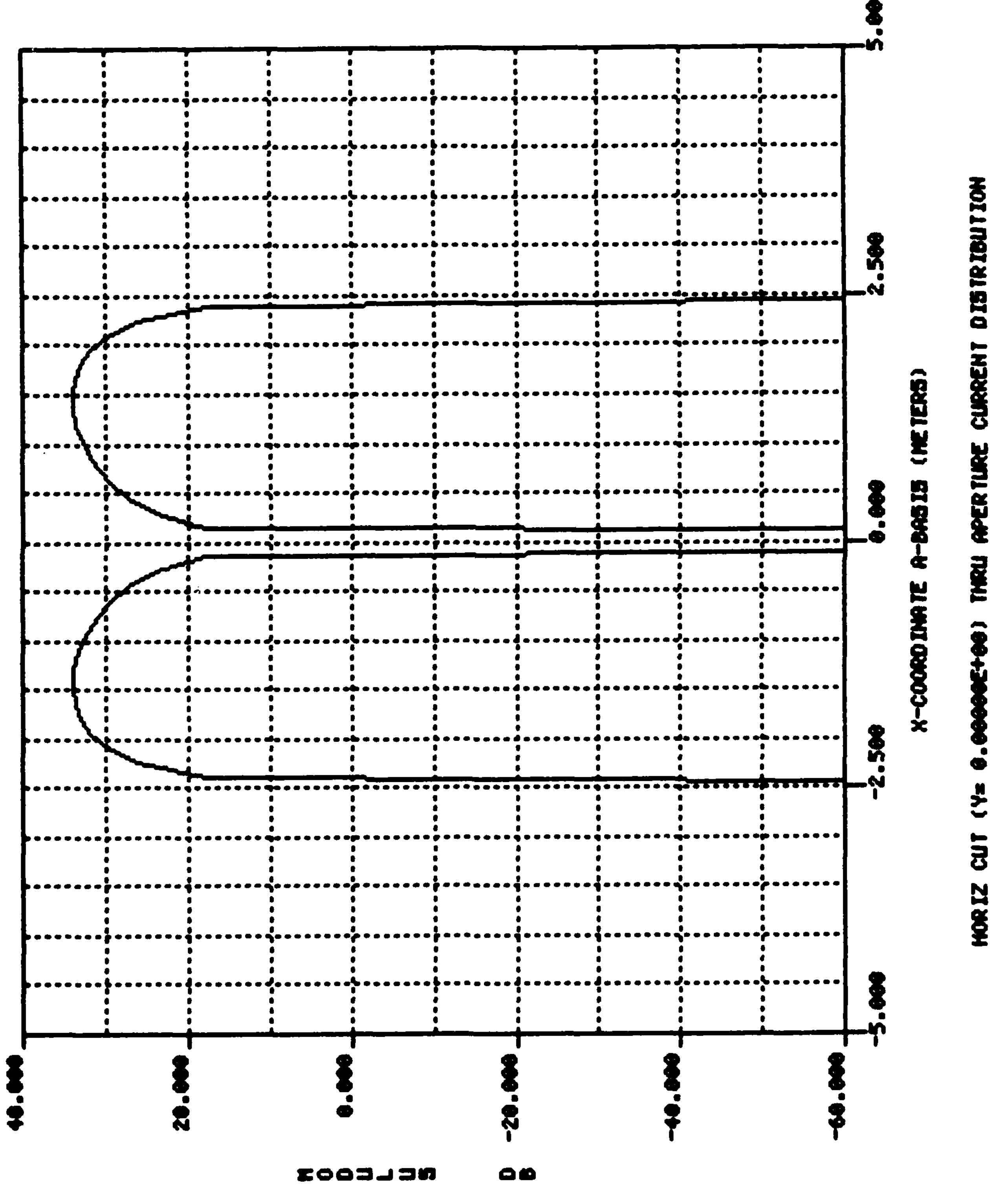
```
SIMSYS
FINST =  1.0000E+00,FOPER  =  1.0000E+00,
$
LATTICE
ILTYPE=          1,COLSPC=  1.5000E-01,ROWSPC=  1.5000E-01,
$
RSHAPE
XWIDTH=  5.0000E+00,YHIGH  =  1.0000E+01,WTXRAD=  2.4750E+00,WTYRAD=  5.0250E+00,
$
WITSYS
IWTFLG=          7,
$
CUBK   =  5.0000E+01,
$
SPAFED
XNFEDA=  0.0000E+00,YNFEDA=  0.0000E+00,ZNFEDA=  1.0000F+01,XAFEDA=  0.0000E+00,
YAFEDA=  0.0000E+00,ZAFEDA=  1.0000E+01,
$
PLARY
NO
IBSFLG=          0,XBEAMT=  0.0000E+00,YBEAMT=  0.0000E+00,NBITS =          28,
LSBRND=          0,IROFF  =           1,ITAPER=           1,DENMAX=  1.0000E+00,
IQ4    =         2,
$
XFORM
NO
YES
N2     =         8,TXCENT=  0.0000E+00,TYCENT=  0.0000E+00,TXSPAN=  1.5000E+00,
TYSPAN=  1.5000E+00,
$
TCS
IGRDF  =        -1,IBAUD  =        9600,ICAPLB=           1,
$
CLOSER
```

VI. OUTPUT DATA

A. PATCUT was used to plot the radiation distribution pattern on the aperture. Both the horizontal and vertical cuts are shown since they are different in this test case. These plots are shown in figures one (1) and one point one (1.1) respectively. This command was also used to generate the horizontal and vertical cut on the far-field radiation pattern seen in figures three (3) and four (4) respectively.

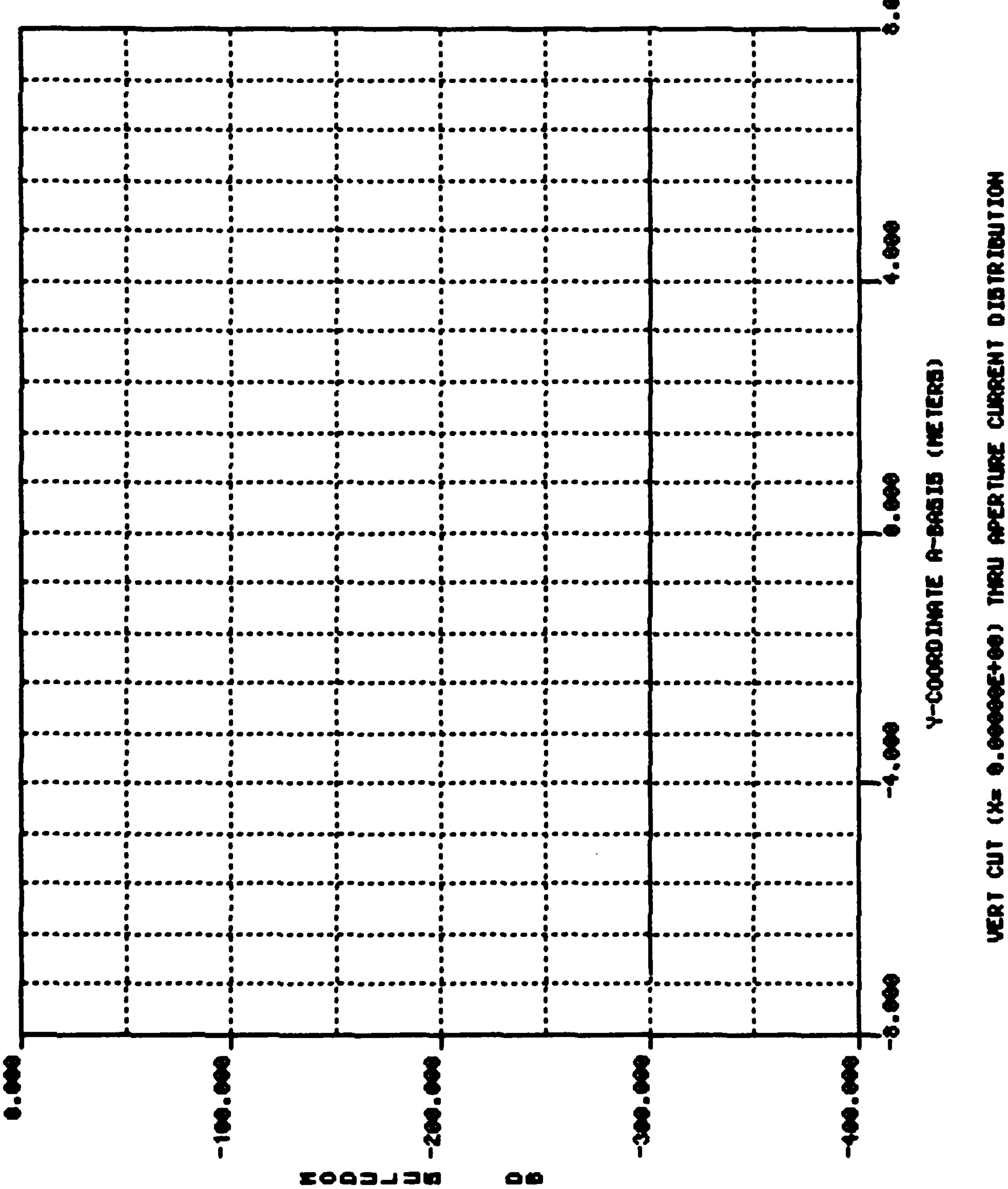
B. PLOT3D was used to plot the three dimensional graph of the far-field radiation pattern that is seen in figure two (2).

FIGURE #1



5.000
2.500
0.000
-2.500
-5.000
X-COORDINATE A-BASIS (METERS)
HORIZ CUT (Y= 0.00000E+00) THRU APERTURE CURRENT DISTRIBUTION
40.000
20.000
0.000
-20.000
-40.000
-60.000
DB

FIGURE #1.1



VERT CUT (X= 0.0000E+00) THRU APERTURE CURRENT DISTRIBUTION
Y-COORDINATE A-BASIS (METERS)
8.000
4.000
0.000
-4.000
-8.000
0.000
-100.000
-200.000
-300.000
-400.000

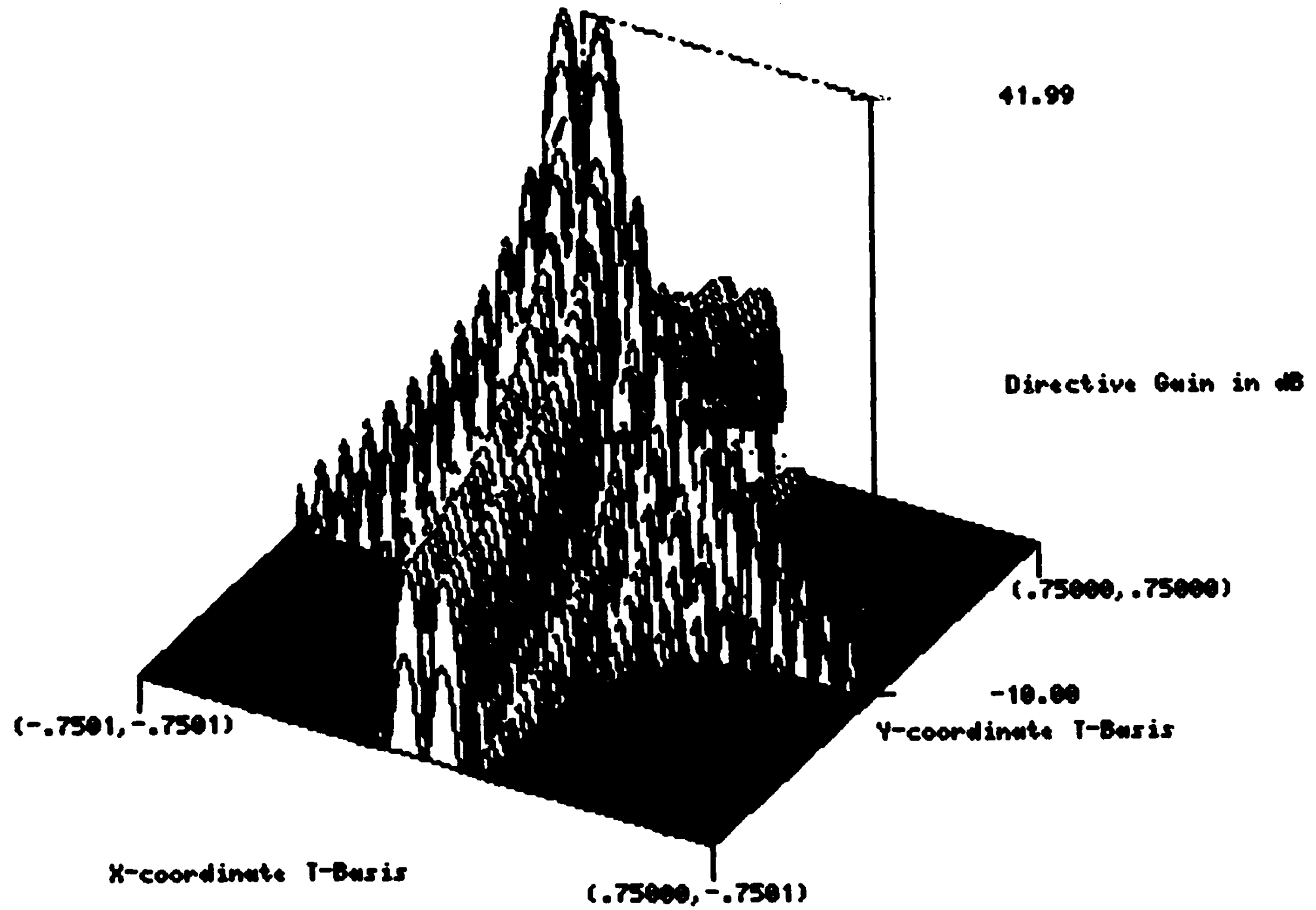
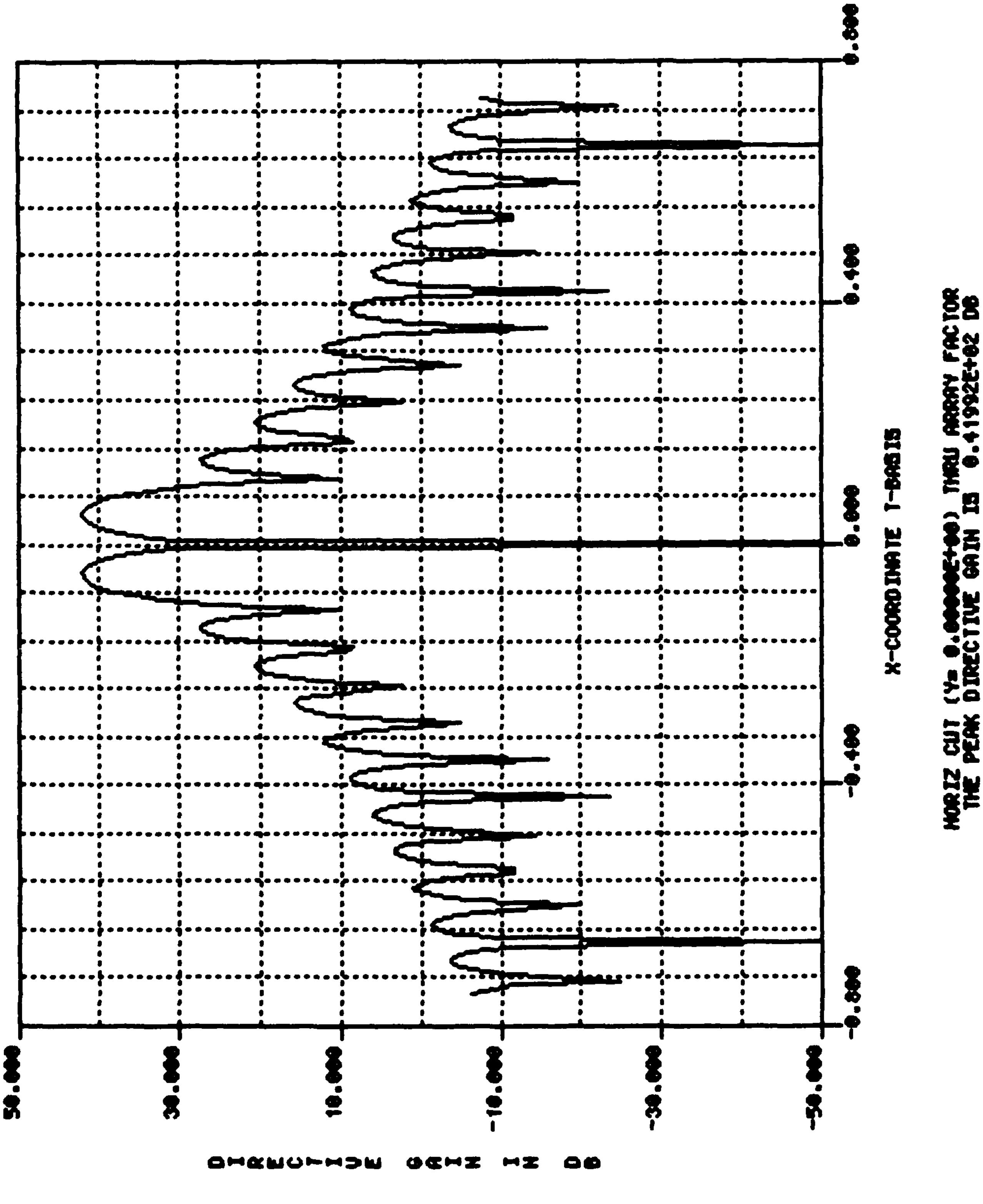


FIGURE #2

Surface Diagram of the Array Factor

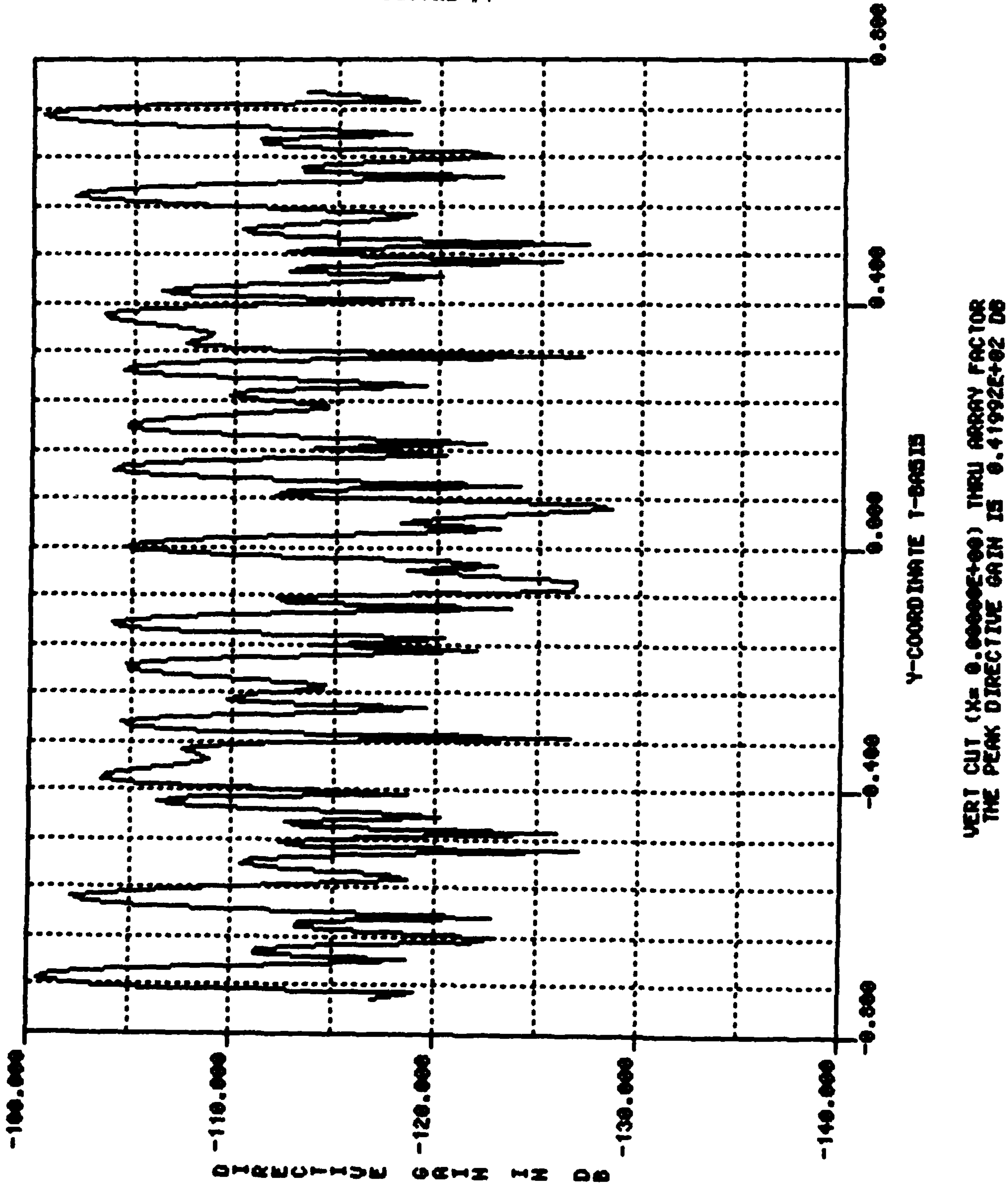
THE PEAK DIRECTIVE GAIN IS 41.992DB

FIGURE #3



50.000
30.000
10.000
-10.000
-30.000
-50.000
DIRECTIVE GAIN IN DB
-0.800
-0.400
0.000
0.400
0.800
X-COORDINATE T-BASIS
HORIZ CUT (Y= 0.00000E+00) THRU ARRAY FACTOR
THE PEAK DIRECTIVE GAIN IS 0.41992E+02 DB

FIGURE #4



-100.000
-110.000
-120.000
-130.000
-140.000
DIRECTIVE GAIN IN DB
-0.800
-0.400
0.000
0.400
0.800
Y-COORDINATE Y-BASIS
VERT CUT (X= 0.000000E+00) THRU ARRAY FACTOR
THE PEAK DIRECTIVE GAIN IS 0.41992E+02 DB

TEST CASE #8

I. PURPOSE

The purpose of this test case is to show the aperture radiation pattern and far-field pattern for an ideal simulation with Gaussian weighting. The additional parameter for this test case is the Gaussian scale factor, which is set at 5.0.

II. SYSTEM DESCRIPTION

Frequency:	1.0 GHz
Feed:	Ideal Space Feed
Dimensions:	Height: 10.0 meters
	Width: 5.0 meters
Elements:	28 Bit Phase Shifters
	Isotropic Radiators
Element Spacing:	0.15 meters apart
	Rectangular Lattice

III. WEIGHTING FUNCTION EQUATION

$$w(t) = EXP[(-0.5\ ALPHA/WTRAD)^2 (RAD)^2]$$

where ALPHA = Gaussian weighting function parameter

WTRAD = maximum element radius

RAD = element radial location

VI. RESULT ANALYSIS

With Gaussian aperture weighting the main lobe had a directive gain of 35.43 decibels. In the horizontal direction the width of the main lobe was 8.05 degrees, and there were no side lobes. In the vertical direction the main lobe was 4.01 degrees wide, and there were no side lobes. The main lobe measurements were made three decibels from the top of the lobe.

V. SIMULATION RUN FILE

```
SIMSYS
FINST =  1.0000E+00, FOPER =  1.0000E+00,
$
LATTICE
ILTYPE=             1, COLSPC=  1.5000E-01, ROWSPC=  1.5000E-01,
$
RSHAPE
XWIDTH=  5.0000E+00, YHIGH =  1.0000E+01, WTXRAD=  2.4750E+00, WTYRAD=  5.0250E+00,
$
WITSYS
IWTFLG=             9,
$
ALPHA =  5.0000E+00,
$
SPAFED.
XNFEDA=  0.0000E+00, YNFEDA=  0.0000E+00, ZNFEDA=  1.0000E+01, XAFEDA=  0.0000E+00,
YAFEDA=  0.0000E+00, ZAFEDA=  1.0000E+01,
$

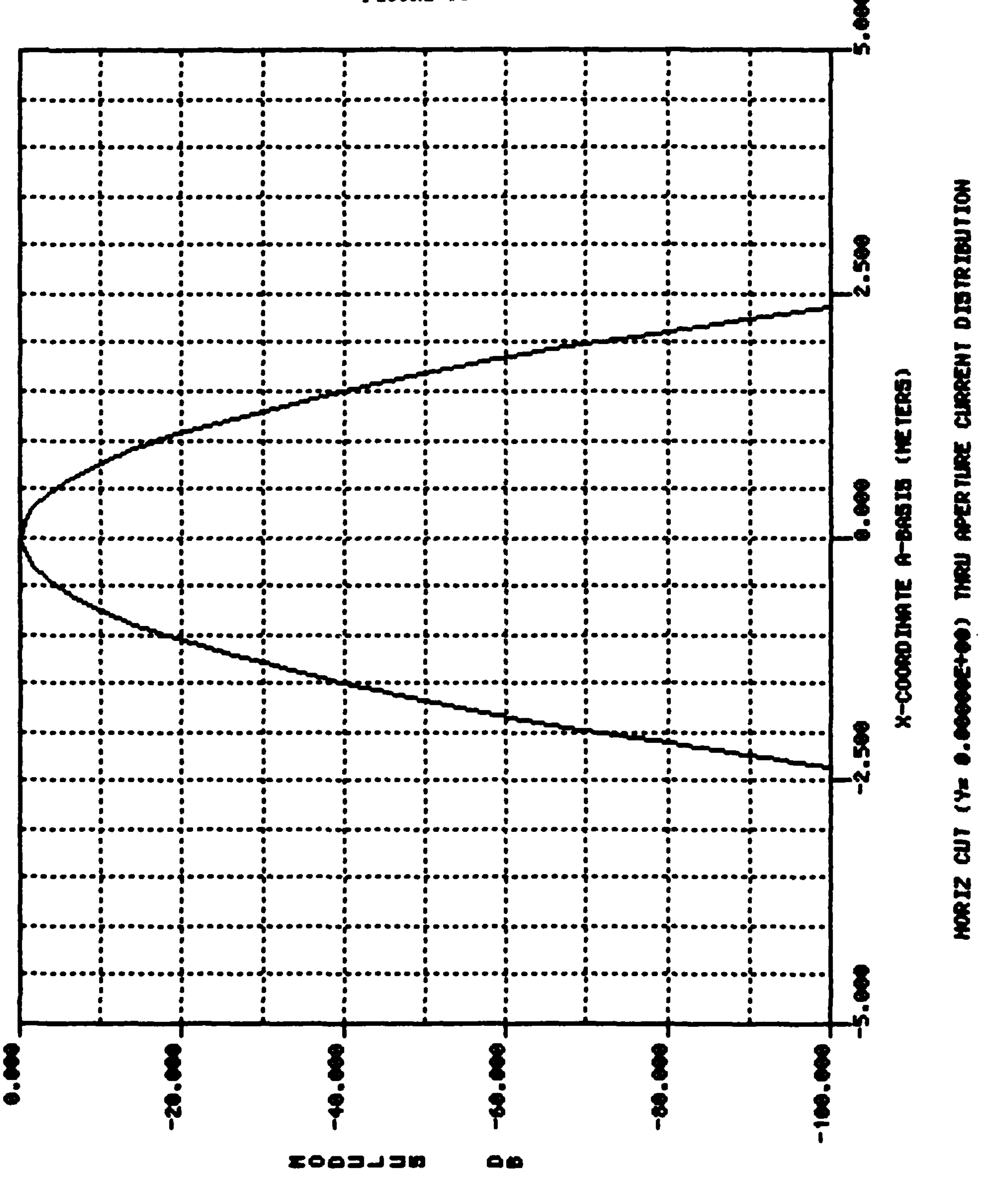
PLARY
NO
IBSFLG=             0, XBEAMT=  0.0000E+00, YBEAMT=  0.0000E+00, NBITS =            28,
LSBRNU=             0, IROFF =             1, ITAPER=             1, DENMAX=  1.0000E+00,
IQ4   =             2,
$
XFORM
NO
YES
N2    =             8, TXCENT=  0.0000E+00, TYCENT=  0.0000E+00, TXSPAN=  1.5000E+00,
TYSPAN=  1.5000E+00,
$
TCS
IGRDF =            -1, IBAUD =          9600, ICAPLB=             1,
$
CLOSER
```

VI. OUTPUT DATA

A. PATCUT was used to plot the radiation distribution pattern on the aperture that is seen in figure one (1). Only the horizontal cut is shown since the overall shape of the horizontal and vertical cuts is the same. This command was also used to generate the horizontal and vertical cuts of the far-field radiation pattern seen in figures three (3) and four (4) respectively.

B. PLOT3D was used to plot the three dimensional graph of the far-field radiation pattern that is seen in figure two (2).

FIGURE #1


HORIZ CUT (Y= 0.0000E+00) THRU APERTURE CURRENT DISTRIBUTION
X-COORDINATE A-BASIS (METERS)
5.000
2.500
0.000
-2.500
-5.000
0.000
-20.000
-40.000
-60.000
-80.000
-100.000

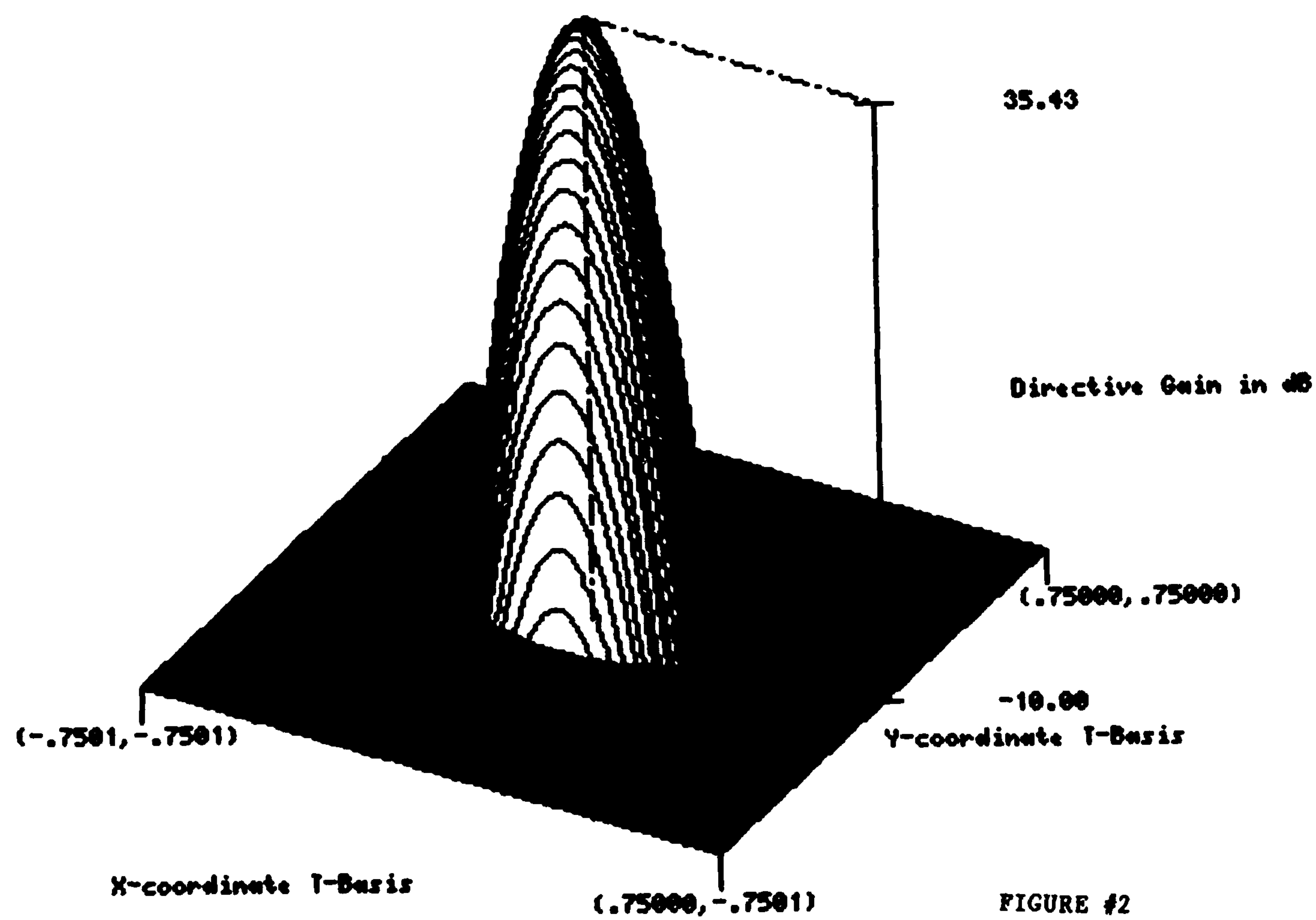
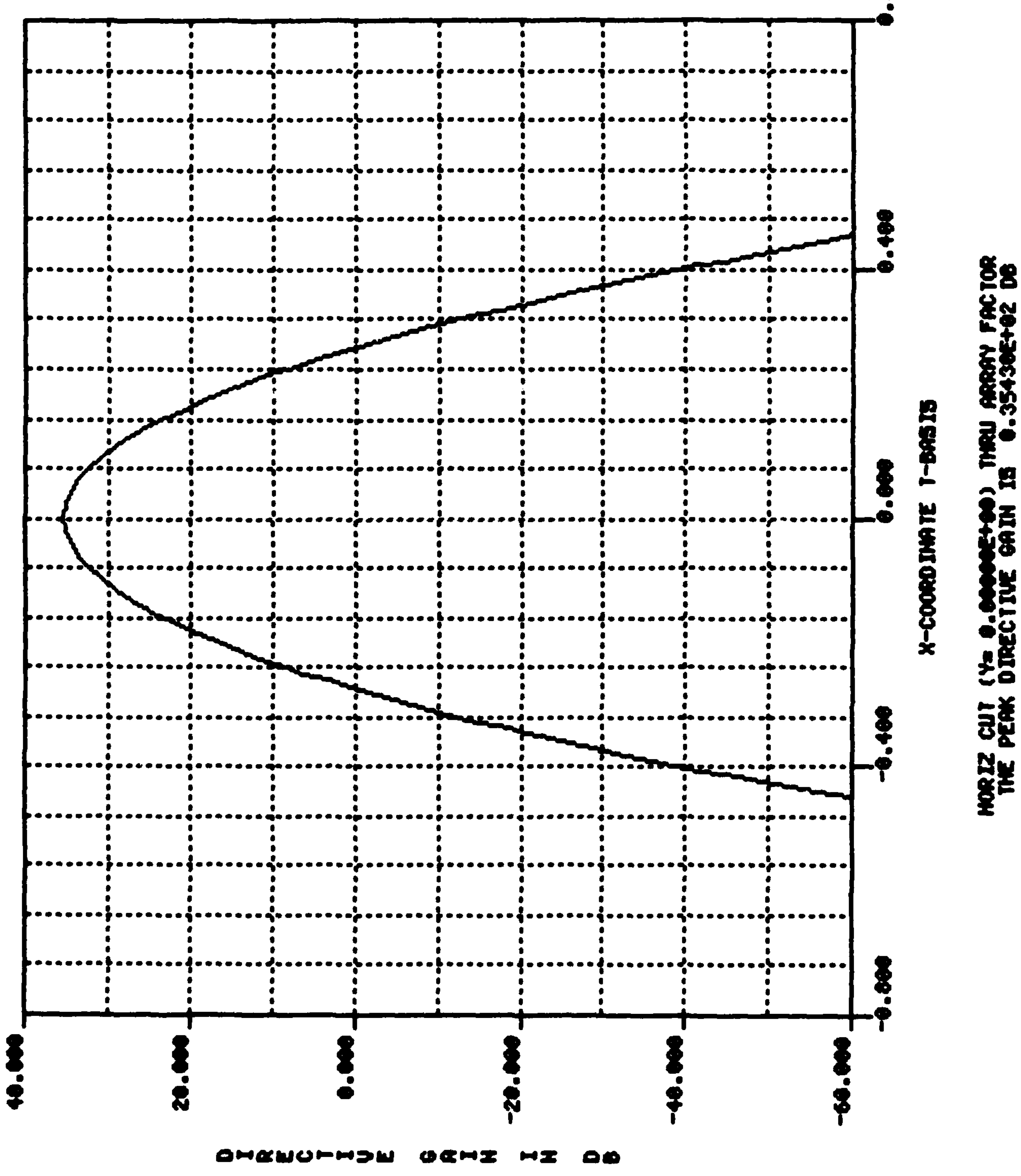


FIGURE #2

Surface Diagram of the Array Factor

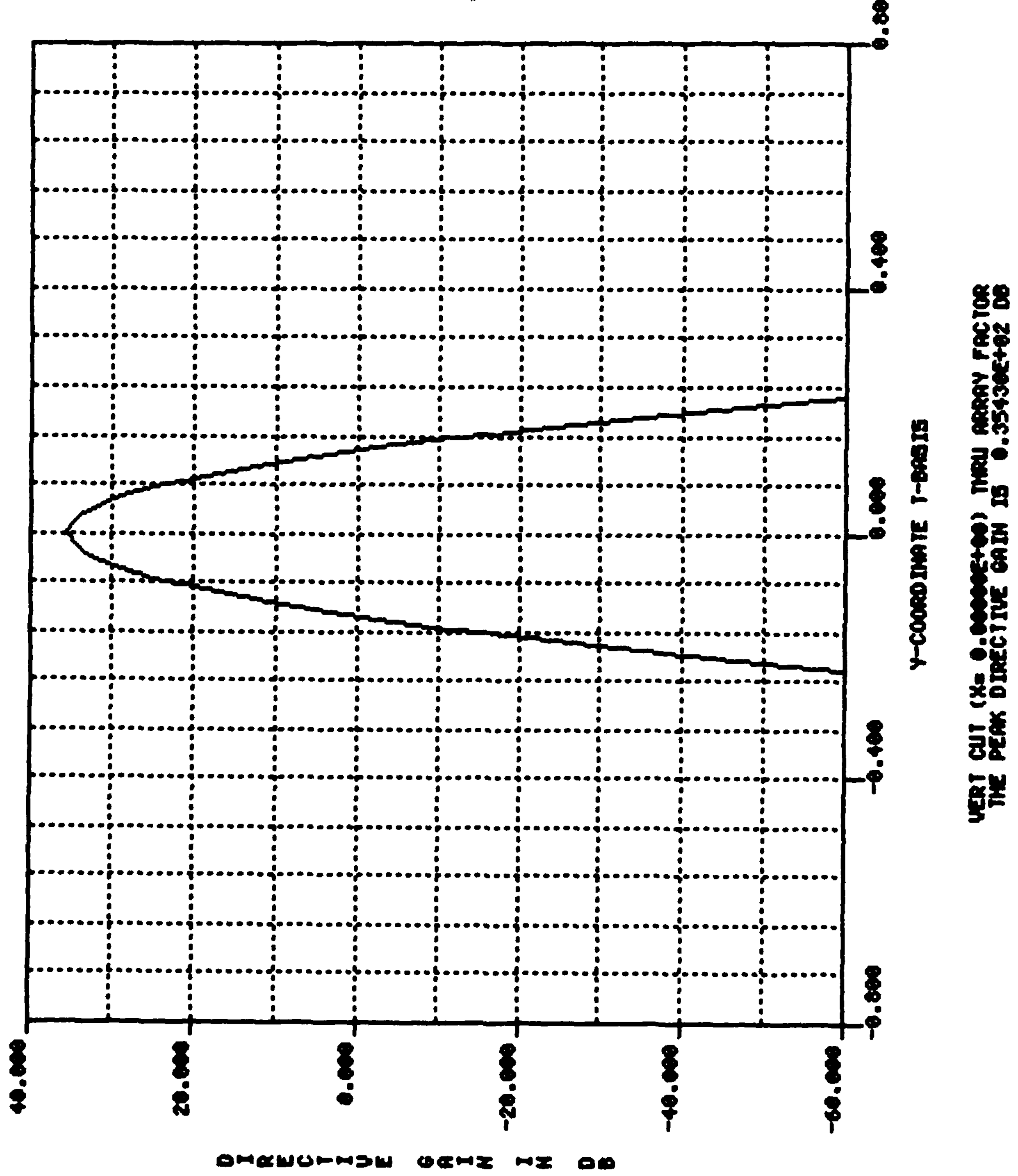
THE PEAK DIRECTIVE GAIN IS 35.430DB

FIGURE #3



0.800
0.400
0.000
-0.400
-0.800
40.000
20.000
0.000
-20.000
-40.000
-60.000
X-COORDINATE T-BASIS
HORIZ CUT (Y= 0.00000E+00) THRU ARRAY FACTOR
THE PEAK DIRECTIVE GAIN IS 0.35430E+02 DB
DIRECTIVE GAIN IN DB

FIGURE #4



0.800
0.400
0.000
-0.400
-0.800
40.000
20.000
0.000
-20.000
-40.000
-60.000
Y-COORDINATE T-BASIS
VERT CUT (X= 0.00000E+00) THRU ARRAY FACTOR
THE PEAK DIRECTIVE GAIN IS 0.35430E+02 DB
DIRECTIVE GAIN IN DB

TEST CASE #9

I. PURPOSE

The purpose of this test case is to show the aperture radiation pattern and far-field pattern for an ideal simulation with Linear Taylor weighting. Additional parameters for this test case are the desired main lobe to side lobe ratio in decibels, set at 60, and the number of zeros used in approximating the Dolph-Chebyshev weighting function, specified at 12.

II. SYSTEM DESCRIPTION

Frequency;	1.0 GHz
Feed:	Ideal Space Feed
Dimensions:	Height: 10.0 meters
	Width: 5.0 meters
Elements:	28 Bit Phase Shifters
	Isotropic Radiators
Element Spacing:	0.15 meters apart
	Rectangular Lattice

III. WEIGHTING FUNCTION EQUATION

$$w(t) = F(1) + \sum_{I=2}^{NBAR} F(I)[\cos([CON(RAD)I/WTRAD](RAD)(I-1))]$$

where RAD = element radial location

F = storage array for coefficients

WTRAD = maximum element radius

CON = PI/WTRAD

P = CON(RAD)

NBAR = number of zeros used in Dolph-Chebyshev weighting

IV. RESULT ANALYSIS

With Linear Taylor aperture weighting the main lobe had a directive gain of 40.65 decibels. In the horizontal direction the side lobes were 60 decibels down and the deepest null was 31 decibels long. The width of the main lobe was 4.01 degrees. The deepest null in the vertical direction was 29 decibels, while the main lobe was 1.72 degrees wide and the first side lobes were 60 decibels down. The main lobe measurements were made three decibels down from the top of the lobe.

V. SIMULATION RUN FILE

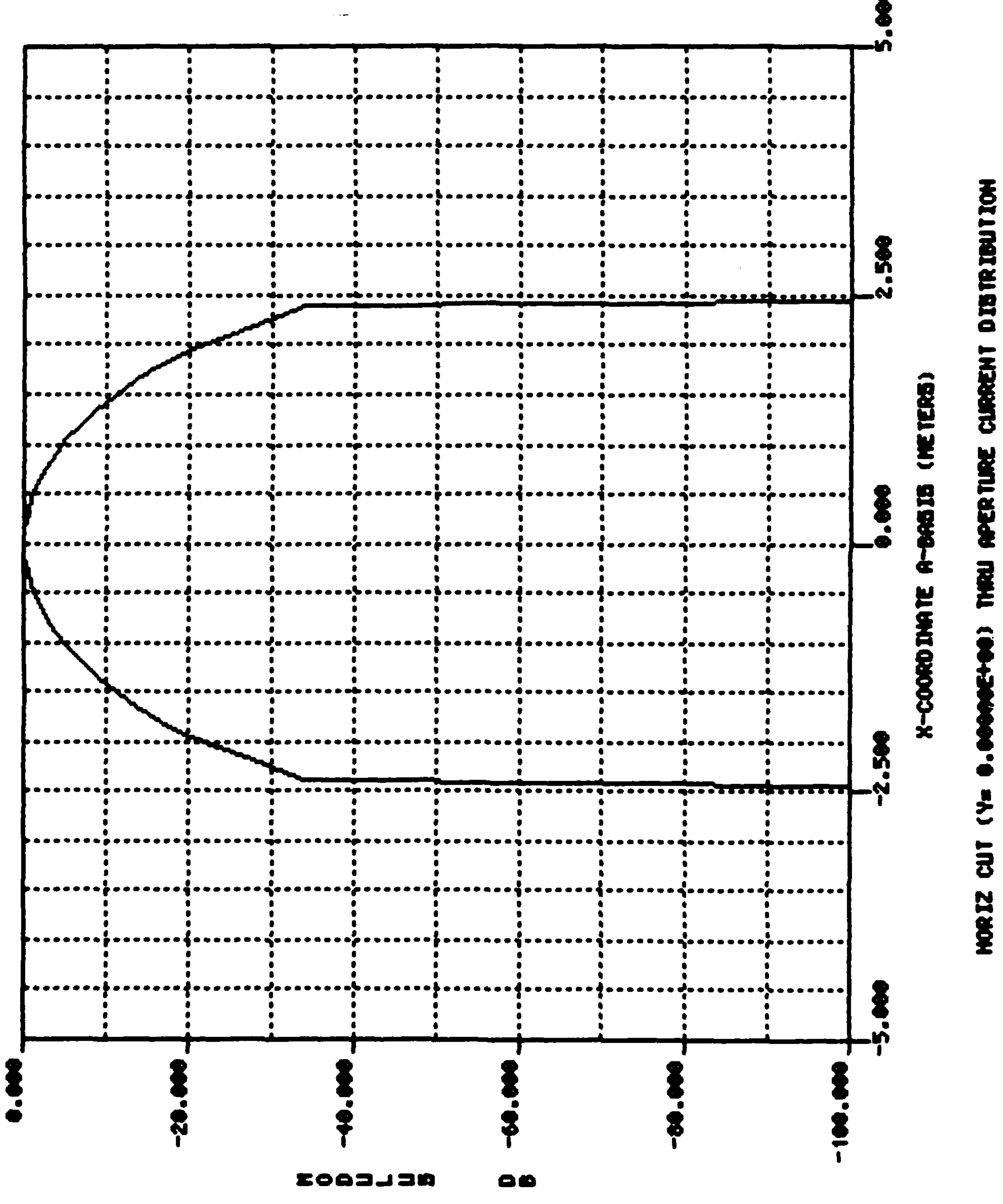
```
SIMSYS
FINST =   1.0000E+00, FOPER  =   1.0000E+00,
$
LATTICE
ILTYPE=              1, COLSPC=  1.5000E-01, ROWSPC=  1.5000E-01,
$
RSHAPE
XWIDTH=  5.0000E+00, YHIGH  =   1.0000E+01, WTXRAD=  2.4750E+00, WTYRAD=  5.0250E+00,
$
WITSYS
IWTFLG=         11,
$
DB     =  6.0000E+01, NBAR   =           12,
$
SPAFED
XNFEDA=  0.0000E+00, YNFEDA=  0.0000E+00, ZNFEDA=  1.0000E+01, XAFEDA=  0.0000E+00,
YAFEDA=  0.0000E+00, ZAFEDA=  1.0000E+01,
$
PLARY
NO
IBSFLG=              0, XBEAMT=  0.0000E+00, YBEAMT=  0.0000E+00, NBITS  =          28,
LSBRND=              0, IROFF  =            1, ITAPER=            1, DENMAX=  1.0000E+00,
IQ4    =             2,
$
XFORM
NO
YES
N2     =             8, TXCENT=  0.0000E+00, TYCENT=  0.0000E+00, TXSPAN=  1.5000E+00,
TYSPAN=  1.5000E+00,
$
TCS
IGRDF  =            -1, IBAUD  =         9600, ICAPLB=            1,
$
CLOSER
```

VI. OUTPUT DATA

A. PATCUT was used to plot the radiation distribution pattern on the aperture that is seen in figure one (1). Only the horizontal cut is shown since the overall shape of the horizontal and vertical cuts is the same. This command was also used to generate the horizontal and vertical cuts of the far-field radiation pattern seen in figures three (3) and four (4) respectively.

B. PLOT3D was used to plot the three dimensional graph of the far-field radiation pattern that is seen in figure two (2).

FIGURE #1



HORIZ CUT (Y= 0.0000E+00) THRU APERTURE CURRENT DISTRIBUTION
X-COORDINATE A-BASIS (METERS)
5.000
2.500
0.000
-2.500
-5.000
0.000
-20.000
-40.000
-60.000
-80.000
-100.000

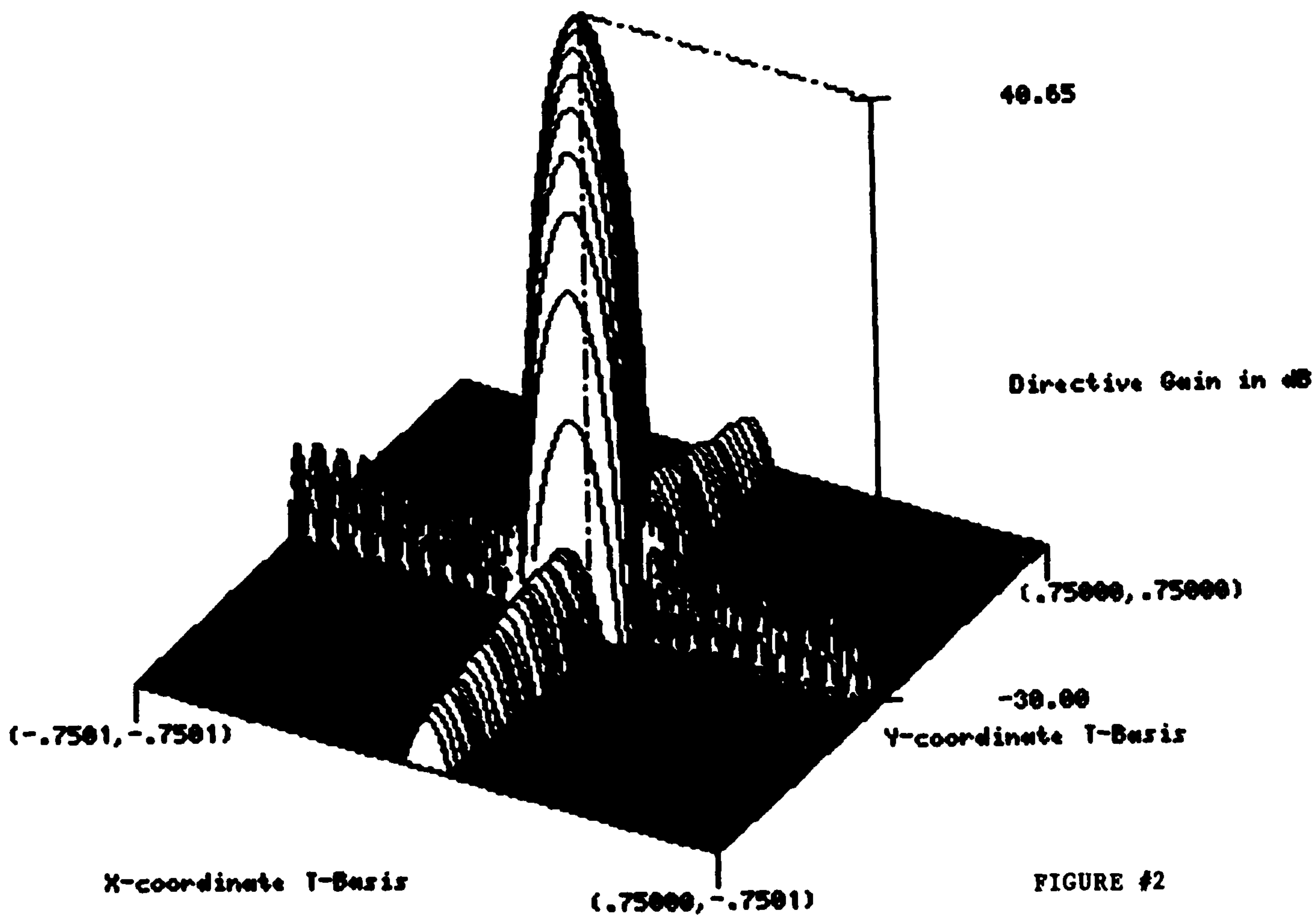
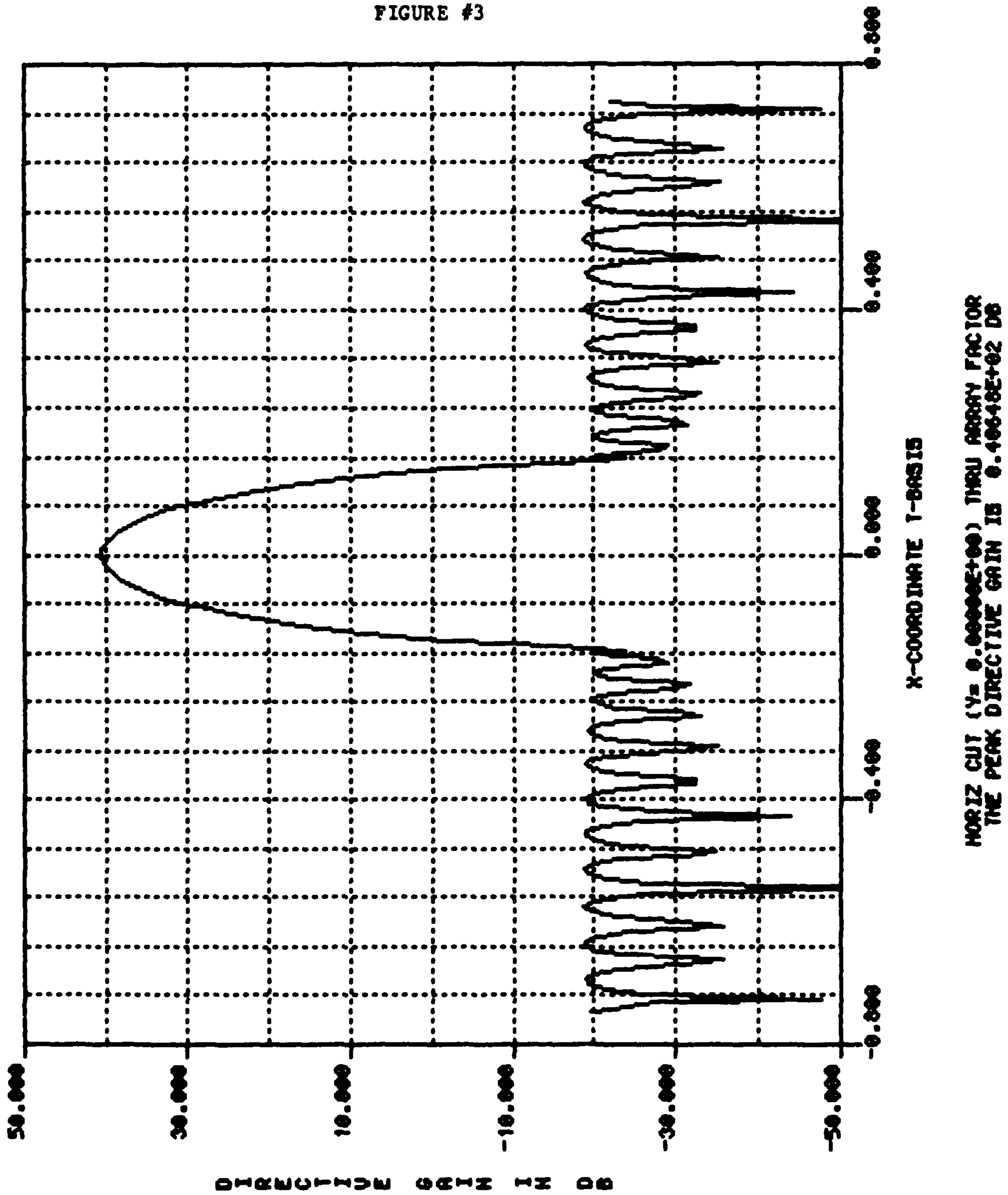


FIGURE #2

Surface Diagram of the Array Factor

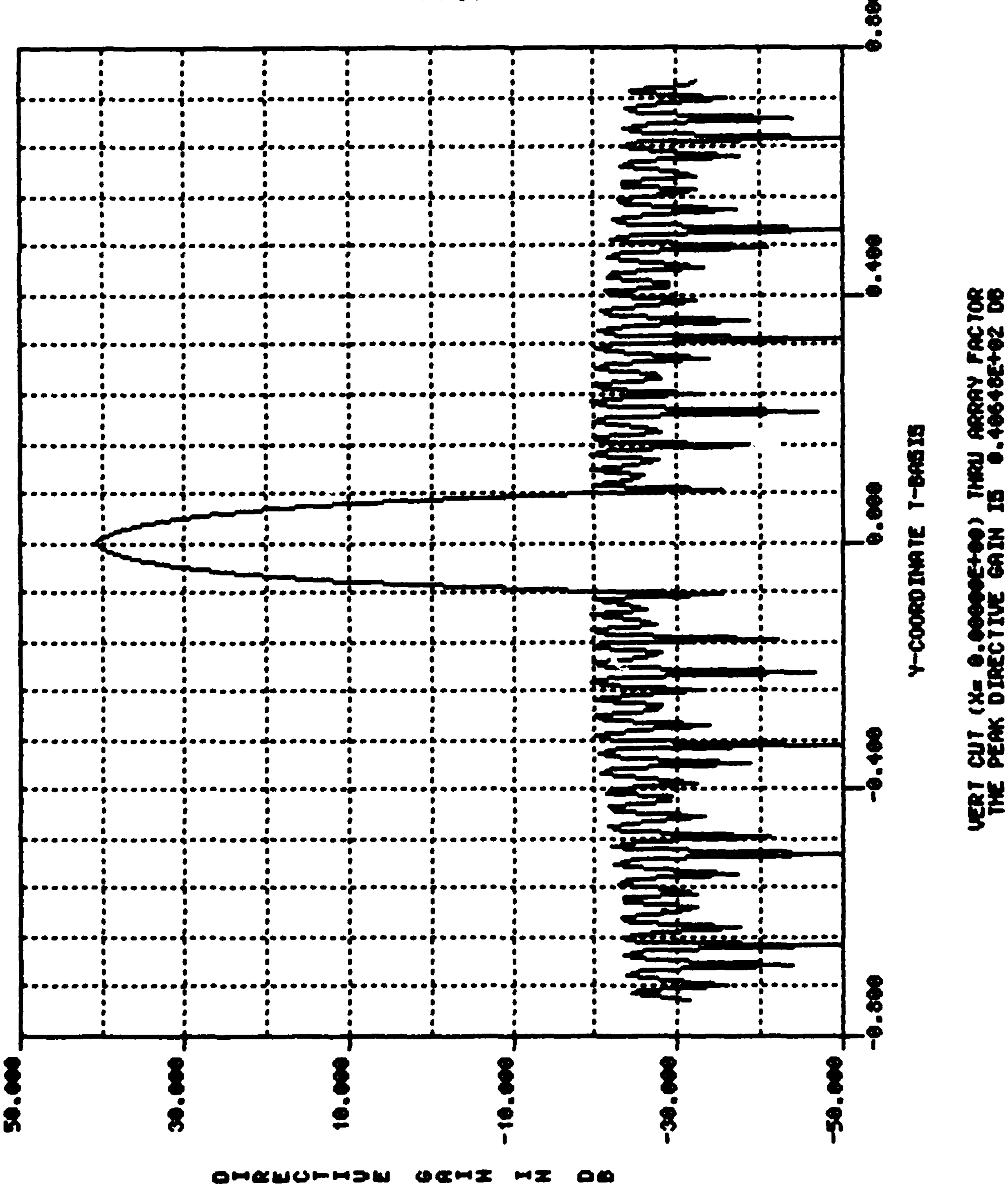
THE PEAK DIRECTIVE GAIN IS   40.648DB

FIGURE #3



50.000
30.000
10.000
-10.000
-30.000
-50.000
DIRECTIVE GAIN IN DB
-0.800
-0.400
0.000
0.400
0.800
X-COORDINATE T-BASIS
HORIZ CUT (Y= 0.0000E+00) THRU ARRAY FACTOR
THE PEAK DIRECTIVE GAIN IS 0.4064E+02 DB

FIGURE #4



0.800
0.400
0.000
-0.400
-0.800
50.000
30.000
10.000
-10.000
-30.000
-50.000
DIRECTIVE GAIN IN DB
Y-COORDINATE T-BASIS
VERT CUT (X= 0.00000E+00) THRU ARRAY FACTOR
THE PEAK DIRECTIVE GAIN IS 0.40648E+02 DB

CONCLUSION

The various weighting functions used on phased array radars serve to change the radiation pattern on the aperture itself in order to achieve more desirable results in the far-field patterns. Engineers wish to see a narrow, focused mainlobe with small sidelobes and deep nulls. In this simulation experiment, the weighting functions were changed within the same design parameters in order to gauge the effect of each function on the far-field pattern. Although these test cases can not be accurately compared to see which is more advantageous due to the different variables involved with each weighting function, the change in the far-field pattern from the nominal, uniformly weighted case can be observed.

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McKay, Jeffrey A. and Bellah, Paul E. SBR Clutter Background Program Maintenance Manual - Parametric Antenna Analysis Subsystem. (Greenville, Simulation Technology, Inc., 1988) part 3, pp. 653-665.

Stanley, William D., et.al. Digital Signal Processing. (Reston, Reston Publishing Company, Inc., 1984) pp. 231, 232, 242.

Benjamin Dreidel

Final Report Number 86

No Report Submitted

Subliminal Communication

by

Stephanie M. Hurlburt

Rome Air Development Center
Universal Energy Systems
Bernard Rydelek
August 31, 1989

II. Acknowledgements

I would like to thank all of those who helped me throughout my summer apprenticeship. First, I would like to thank my mentor, Bernie Rydelek, for giving me the opportunity to work at RADC under the summer apprenticeship program. Bernie took time from his very busy schedule to teach me a little about subliminal audio, signals, speech, and speech processing. Whenever Bernie was away, I would turn to Andy Kozak for any questions that I might have. On my computer programming, I would like to thank Major Richard Floyd. He too, was a very busy person, but he would always take the time to show me anything I needed on the computers. Last, I would like to thank John Grieco and Mike Cook from the speech processing lab, who put up with all my questions on how everything worked, giving me a chance to work with the equipment, letting me help with the demonstrations, and for not letting me give up when I would get frustrated. There were many others that helped me along with my project when I needed it, but I am unable to mention them all. Thank you all, so very much, for all the opportunities and experiences that you have given me throughout this summer.

III. Introduction

Often people are fascinated by things that they are unsure of, the world of the unknown. Wondering who, what, and why. Questioning the purpose and effect. Subliminal communication is based on the idea that we can detect information presented below our threshold of awareness. People exposed to subliminal messages may not consciously see or hear anything beyond the obvious, but they are supposed to be aware of the message at an unconscious level. Enough research exists on subliminal perception to establish it is a psychological phenomenon, but psychologists say more research is needed especially with tapes. Further research could help establish how far below threshold messages can be presented and still be processed and what role defense mechanisms play. [1]

IV. Subliminal Communication

A psychology major announced that he discovered a technique whereby irresistible advertising messages could be delivered to consumers without their knowledge. [32]

Subliminal means "below threshold." However, there is no absolute cutoff point below which stimulation is imperceptible and above which it is always detected. Instead, a particular stimulus is sometimes detected and sometimes undetected. As a result, a person's perceptual threshold is usually defined as the stimulus intensity that is correctly detected as fifty percent of the time. [33]

A century of psychological research supports the general principle that the more intense the stimulus, the more effect it will have on our behavior. To propose that people can be affected in important ways by stimuli so weak that their mere presence is undetectable is an extraordinary claim that should not be accepted without clear, well-replicated evidence. [34]

Although we are unable to consciously perceive the content of visual or auditory stimulus exposed to the eyes or ears at a level below normal threshold, it is possible to perceive the subliminal stimuli unconsciously or through some other unknown mechanism of the mind. The subliminal stimulus appears to connect with existing unconscious memories. [35]

In 1964-65 Bicker (**et al**) reported definitive results from experiments in which geometric symbols and trade names were displayed subliminally, concurrently with a supraliminal color, sound motion picture cartoon. [4]

Additional papers by Becker (**et al**) have described the successful use of video and audio subliminal stimuli in different therapeutic setting ranging from weight control and through smoking deterrence. [5]

How well these messages work seems to depend on the person exposed, but they do not appear to work equally well on everyone, and stimulation does not necessarily trigger action. There are factors, such as how often people listen to or view tapes and how deep-rooted their problems are, that influence how well subliminal messages work. What is subliminal for on person may be plain as day for another. And some people may respond immediately to a subliminal message, while others have a delayed response or no response at all. [6]

The overall results of the study may thus be due to the effects of that stimuli that are weak, but not necessarily subliminal. In order to demonstrate true subliminal perception, care must be taken to ensure that the people involved cannot recognize it. [7]

Earlier use of subliminal communication has been controversial because it influences a person's behavior without his conscious awareness.[10] Some research has shown that subliminal messages can, in certain instances at least, lead people to change their behavior. For some people who have trouble losing weight or refusing cigarettes, for example, subliminal suggestions on audio or video tapes appear to offer help.[11]

To discourage shoplifting, department stores buried "I am honest" messages in their Mazic readings, and to increase sales, real estate companies subjected their agents to tapes with hidden motivational phrases.[12]

Subliminal persuasion used to raise eyebrows. Now it is raising money--and lots of it--for companies claiming that video and audio tapes can persuade people to break habits. These days, the public isn't criticizing use of subliminals--they are buying them. Some resorts use subliminals to help vacationers relax. Computer programs flash subliminal messages during TV shows, and video and audio tapes that offer subliminal solutions for problems ranging from cellulite to stress are hot items at bookstores everywhere.[13]

Subliminal effects have sometimes been attributed to images or words that have been confidently concealed in magazine ads. These embedded stimuli are usually to small or vague to be consciously recognized, but they are declared to influence the viewer's subconscious sex drive. Stimulation below the level of conscious awareness can be shown to have measurable effects. However, the most reliable documented effects are very brief and do not imply. No one has proven that these techniques are effective, but TV networks are so nervous about them, they have burred the use of subliminal techniques in advertising.[14]

Other researchers claimed there was no good evidence that people detected such messages much less acted on them. Besides that, the public refused the idea of being tricked into buying anything. Subsequent public reaction was immediate and overwhelming negative. Fears were expressed that convert mind control become widespread.[15]

The important question is whether these effects justify the claims made for subliminal advertising and other applications. This question is critical because what must be shown is not merely a single effect, but specific, powerful, and enduring effects upon motives, preferences, and/or memory. For the effects to occur there must be an unconscious perception or understanding of the subliminal message. Evidence for such an understanding is nowhere near conclusive.[16] As Ayeh Neies, former executive director of the American Civil Liberties Union, puts it, "People have a right to go about their business without being subjected to manipulation they don't even know about."[17]

In conclusion, I feel that subliminal audio has both advantages and disadvantages. Some of its advantages would be that it would increase people's self-respect and honesty, but its disadvantages are worse. If it managed to get in the wrong hands, it could be a downfall to everything.

V. Comments

This summer was an experience that I will never forget. This was going to be by first research working experience and I was looking forward to it. After working my first three weeks I was very disappointed. My mentor was a very nice person, but he was much too busy to take on the responsibility of being a mentor. He had to leave on business a lot and took his vacation while I was working at first this was no bother, but as time went on the work he had left for me would be completed before he returned or I wouldn't understand what he wanted me to do. So, I would ask others for help, but they were not always sure either. I spent many hours in the library trying to research a topic that I had no knowledge of and very little was known about it. My search seemed to be going nowhere and I was getting very frustrated. He gave me an equation to work on, but until recently I had no idea what it was for. Towards the end of the summer, the job became more informative and I started to understand what was happening. I was finally getting self-satisfaction out of the job. Whether I learned exactly what I was supposed to or not, I did learn what it was like in an engineering environment. I also encountered new experiences that I will always remember. I think this would be an excellent program for any student as long as you know that the student has a mentor that is not too busy for them, they understand what is expected of them, and accomplish self-satisfaction.

Footnotes

1. Natale, JoAnna. "Are you Open to Suggestion?" Psychology Today, September 1988, pp. 28 & 30.

2. Moore, Timothy E. "Subliminal Delusion." Psychology Today, July 1985, pp. 10-11.

3. Ibid.

4. Ibid.

5. "Persuasion in a Flash." Psychology Today, February 1986, p. 50.

6. Becker, Hal C. and N.H. Glanzer. "Subliminal Communication: Advances in Audiovisual Engineering Applications for Behavior Therapy and Education." Proceedings of the 1978 IEEE Region III Conference, April 1978.

7. Becker, Hal C. and Kathleen D. Charbonnet. "Applications of Subliminal Video and Audio Stimuli in Theraputic, Educational, Industrial, and Commercial Settings."

8. Natale, JoAnna. "Are you Open to Suggestion?" Psychology Today, September 1988, pp. 28 & 30.

9. Moore, Timothy E. "Subliminal Delusion." Psychology Today, July 1985, pp. 10-11.

10. Becker, Hal C. and N.H. Glanzer. "Subliminal Communication: Advances in Audiovisual Engineering Applications for Behavior Therapy and Education." Proceedings of the 1978 IEEE Region III Conference, April 1978.

11. Natale, JoAnna. "Are you Open to Suggestion?" Psychology Today, September 1988, pp. 28 & 30.

12. Ibid.

13. Ibid.

14. Moore, Timothy E. "Subliminal Delusion." _Psychology Today_, July 1985, pp. 10-11.

15. Natale, JoAnna. "Are you Open to Suggestion?" _Psychology Today_, September 1988, pp. 28 & 30.

16. Moore, Timothy E. "Subliminal Delusion." _Psychology Today_. July 1985, pp. 10-11.

17. Becker, H.C. "Secret Voices." _Time_, September 10, 1979, p. 71.

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"Persuasion in a Flash." Psychology Today, February 1986, p. 50.

Michael Marko

Final Report Number 88

No Report Submitted

1989 USAF-UES HIGH SCHOOL APPRENTICESHIP PROGRAM

SPONSORED BY THE
AIR FORCE OFFICE OF SCIENTIFIC REASEARCH

CONDUCTED BY
UNIVERSAL ENERGY SYSTEMS, INC.

FINAL REPORT
PROBABILITY AND RANDOM TEST LENGTH

PREPARED BY: KAREN PANEK

RESEARCH LOCATION: ROME AIR DEVELOPMENT CENTER

USAF MENTOR: KEVIN KWIAT

DATE: AUGUST, 15, 1989

ACKNOWLEDGEMENTS

My most sincere thanks to my mentor, Mr. Kevin Kwiat, for giving me this chance to work at RADC. I greatly appreciate the help I received from Mr. Kwiat, Dr. Warren Debany, Mr. Anthony Macera, Mr. Mark Gorniak, and Ms. Heather Dussault. A special thanks to a RBRA Fellowship student, Dan Daskiewich, for explaining programming and probability concepts to me, and for introducing me to other summer students. My involvement in the High School Apprenticeship Program has given me experience in many different aspects of the work environment which will prepare me for college and for future jobs.

I have almost completed my 1989 summer employment in the High School Apprenticeship Program (HSAP) at Rome Air Development Center (RADC) on Griffiss Air Force Base (GAFB) in Rome, New York. I have worked as a scientific aide for my mentor, Mr. Kevin Kwiat and his boss, Dr. Warren Debany, at the Reliability Assurance Branch (RBRA). RBRA prepares specifications, test methods, and quality conformance procedures for microcircuits intended for military and aerospace high reliability applications. According to the Mil-Std-721C, reliability can be either "(1) the duration or probability of failure-free performance under stated conditions" or "(2) the probability that an item can perform its intended function for a specified interval under stated conditions." The engineers in the microcircuit testability group develop testing techniques and specifications for complex microcircuits; therefore, the circuits will be ready for use in military systems. My work mainly involved computer programming for the testability group. The support and patience of Mr. Kwiat, Dr. Debany, and the other engineers played an important role in the success of my job.

My 1989 summer job involved complex and detailed concepts relating to my projects. Since I already understood the basics of Programming Language-1 (PL/I) and was familiar with the work environment, I started programming right away. In 1988, I worked on a variety of simpler topics, but this year I focused on a more difficult subject, probability. I also designed a program to help the technical library system here at Rome Griffiss AFB. I gave three presentations this summer; two were presented for the RBRA branch, and the other was presented for the chief engineer at RADC. I attended presentations given by RBRA engineers, Dr. Warren Debany, Mr. Mark Gorniak, and Mr. Anthony Macera. Dr. Debany spoke about Total Quality Management (TQM). He compared the methods of production in Japan and in the United States, and the results of each country's methods. Mr. Gorniak presented a digital circuit model translator. It translates the Hierarchical Integrated Test Simulator (HITS) language to the Non-standard Intermediate Form (NIF) language. This translator is very important and necessary since the NAVY uses the HITS language and our industry uses VHSIC(Very High Speed Integrated Circuits) Hardware Description Language (VHDL). We can translate the NIF language to VHDL, but we needed to translate the HITS language to the NIF language first. Mr. Macera discussed ciruit modeling, fault simulation, and fault coverage.

A large portion of the work I did this summer centered on two related probability problems. The first one is frequently referred to as the "birthday" problem. The "birthday" problem gives the probability that at least one duplicate birthday occurs for n number of people. The assumption is that there are 365 birthdays in a year (excluding the extra few hours, minutes, and seconds that make a year exact), and the birthdays are equally distributed, meaning each birthday has the same probability that it will occur as any other one. Using the equation (FIG.1-1), I demonstrated that by the 83rd person a 99.999% chance of getting a duplicate occurs for 365 birthdays (FIG.2-1). When the figures are plotted on a graph, they reveal the cumulative distribution function (FIG.2-2).

Once I understood the "birthday" problem, I related its concepts to the digital self-testing method. I substituted the number of tests for the number of people, and I allowed the tests to be inputed as 2^M. Dr. Debany explained an example of using bits as tests (FIG.3). The bits are continually generated and tested. If a duplicate occurs then the testing should be terminated since the rest of the tests are useless. The combinational logic output is carried to the test generator where the output creates the next group of lines to be tested (FIG.4). For 2^{20} test lines or bits (app. 1,000,000) the average number of tests where a duplicate occurs is approximately 1300. This means that after 1300 tests a duplicate will most likely occur, and the following tests will be totally ineffective (FIG.5).

In 1986, Dr. Debany had written a paper with Syracuse University professors, Dr. Pramod Varshney and Dr. Carlos Hartmann, on the subject of random test length with and without replacement. Upon Dr. Debany's request, I wrote a program to demonstrate the equation empirically (FIG.1-2). Therefore, I began the second related probability problem which deals with the relation between random test generation with and without replacement. The variable, n, represents the number of unique tests in an experiment without replacement, and the variable nr represents the tests generated with replacement. For 500 samples in x number of experiments my program calculates the average number of unique tests (FIG.6). Then it compares my experimental average with the average from the equation and figures the percent error.

Dr. Debany then spoke with Dr. Prawha Nagavhara at Boston University and Northeastern University. Dr. Nagavhara had just solved for the inverse of E{n}, which is E{nr}, using very complex formulas. Dr. Debany explained to him about his paper from 1986 and the ideas involved within the paper. Dr. Nagavhara then decided that he would revise his own paper before handing it in. After their conversation, my next project was to solve for nr from the equation of E{n} (FIG.1-2). Once I had E{nr}, I wrote a program to test the validity of the new equation. The inverse equation did not create a true function since it had only one input and several outputs. For a certain number of unique tests, my program finds the average number of tests generated (FIG.1-3). Surprisingly, my values for E{nr} came very close to the calculated values from the equation, giving a very small percent error (FIG.7). Therefore, the program has demonstrated the inverse equation.

A great many people have used the Rolirs Library System at the Griffiss AFB Technical Library since 1987. The computer system allows people to log in from different areas around the base as long as they are on the Data General MV/10000 computer system. The users can search for books by titles, subjects, and authors. A listing on the screen provides the user with the requested information. Dr. Debany has a file of approximately 21,000 lines, which has stored everything that has been typed in by those who have used the Rolirs System for the past two years. Dr. Debany asked me to create a program which would count up just the entry dates for each user in his file. It does not matter when the person logged off or what information was typed in. Before the program reached Jan. 19, 1989 the line it checked for followed the format:

"ROLIRS begin 16-DEC-87 08:19:56"

My program changed the date from dd-mmm-yy(d=day, m=month, y=year) to mm/dd/yy, so that it would be the same as the next type of format. Once the program read in Jan. 19, 1989 the format changed to:

"user: LI; at 06:56:25 on 01/19/89"

When the dates were all read in and in the same form, they were counted for each day, month, and year. The output from my program printed each of the three counts and was used in the Annual Report for library usage by Mr. Mike Heines, the chief librarian at the Tech. Library.

Each of the aforementioned programs enhanced my programming skills. Since I now know three computer languages, BASIC, Pascal, and Programming Language One, I should be well-prepared for my upcoming college computer classes. My three presentations have given me great experience for future presentations in college and in the work field. I have learned to speak clearly, confidently, and concisely when presenting my material. These past two years at RADC in the RBRA section on Griffiss AFB have taught me much more than I could have ever learned school. I am increasingly sure about my decision to study engineering. I enjoyed meeting other summer students at RADC and observing their work. Therefore, I consider myself very fortunate to have had the chance to work with the engineers in the RADC/RBRA branch at Griffiss AFB.

FIG.1

```
******                          *     *
*                               *
*        ****   *   *   ****  *****   *   ***   ****    ****
***     *   *   *   *      *    *     *  *   *  *   *  *      *
*       *   *   *   *   ****    *     *  *   *  *   *  ****
*       *   *   *   *  *   *    *  *  *  *   *  *   *      *  *
******   ****    ****   ****     **   *   ***   *   *  ****
            *
            *   *
              *
```

** eq_1 refers to the "birthday" problem

** eq_2 & eq_3 relate test generation with & without replacement

** eq_3 is the inverse of eq_2

---

eq_1) $\Pr\{\text{duplicate}\} = 1 - \prod_{i=1}^{N-1} (1 - i/M)$ FIG.1-1

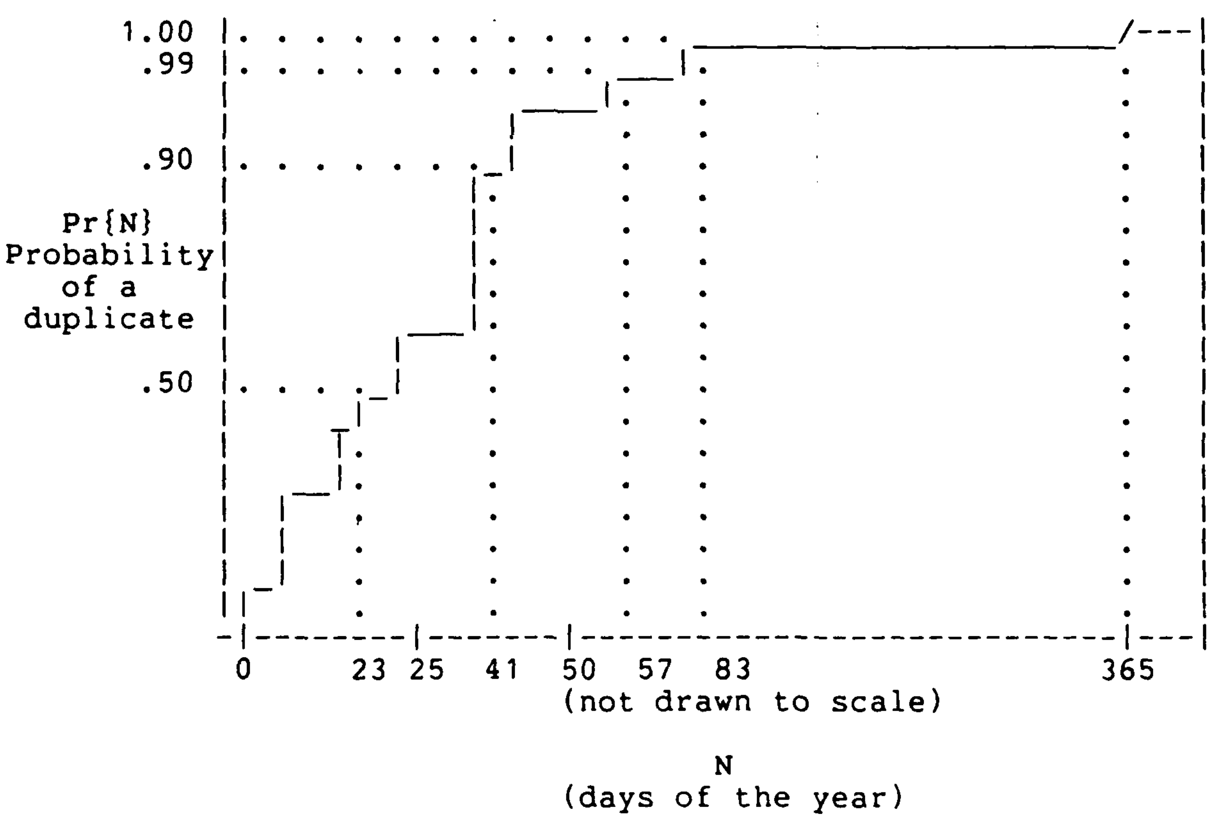
eq_2) $E\{n\} = M\,[\,1 - (1 - 1/M)^{nr}\,]$ FIG.1-2

eq_3) $E\{nr\} = \ln(1 - n/M)/\ln(1 - 1/M)$ FIG.1-3

A. Inverse of $E\{n\} = E\{nr\}$.....$f^{-1}(n)$

FIG.2
(BIRTHDAY PROBLEM)

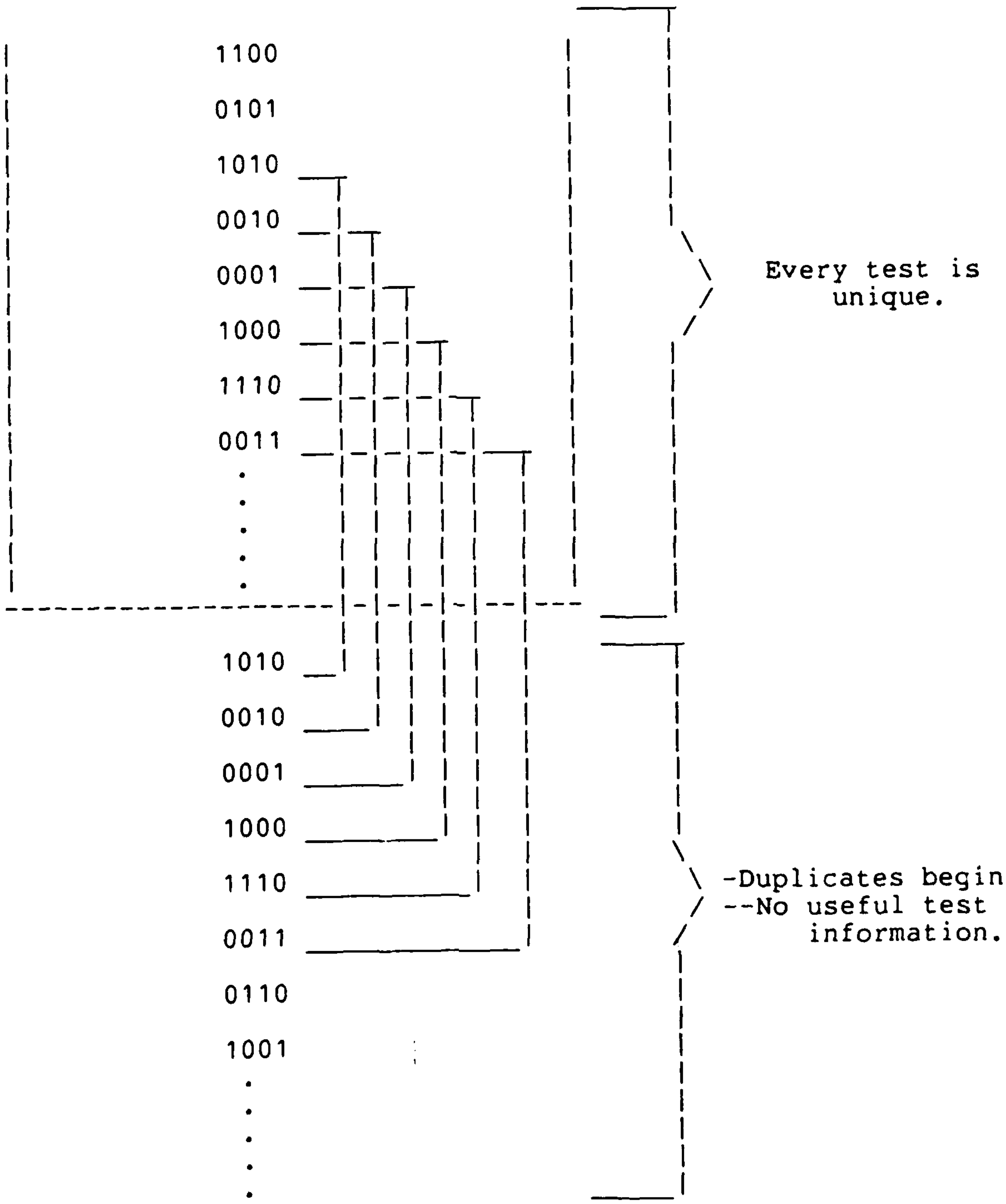
People	Pr{dup with N people}	%
1	0.0000	0.00%
2	.0027	0.27%
3	.0082	0.82%
4	.0164	1.64%
5	.0271	2.71%
10	.1169	11.69%
15	.2529	25.29%
20	.4114	41.14%
25	.5687	56.87%
30	.7063	70.63%
35	.8144	81.44%
40	.8912	89.12%
50	.9704	97.04%
60	.9941	99.41%
70	.9992	99.92%
80	.9999	99.99%



Distribution Function (cumulative)

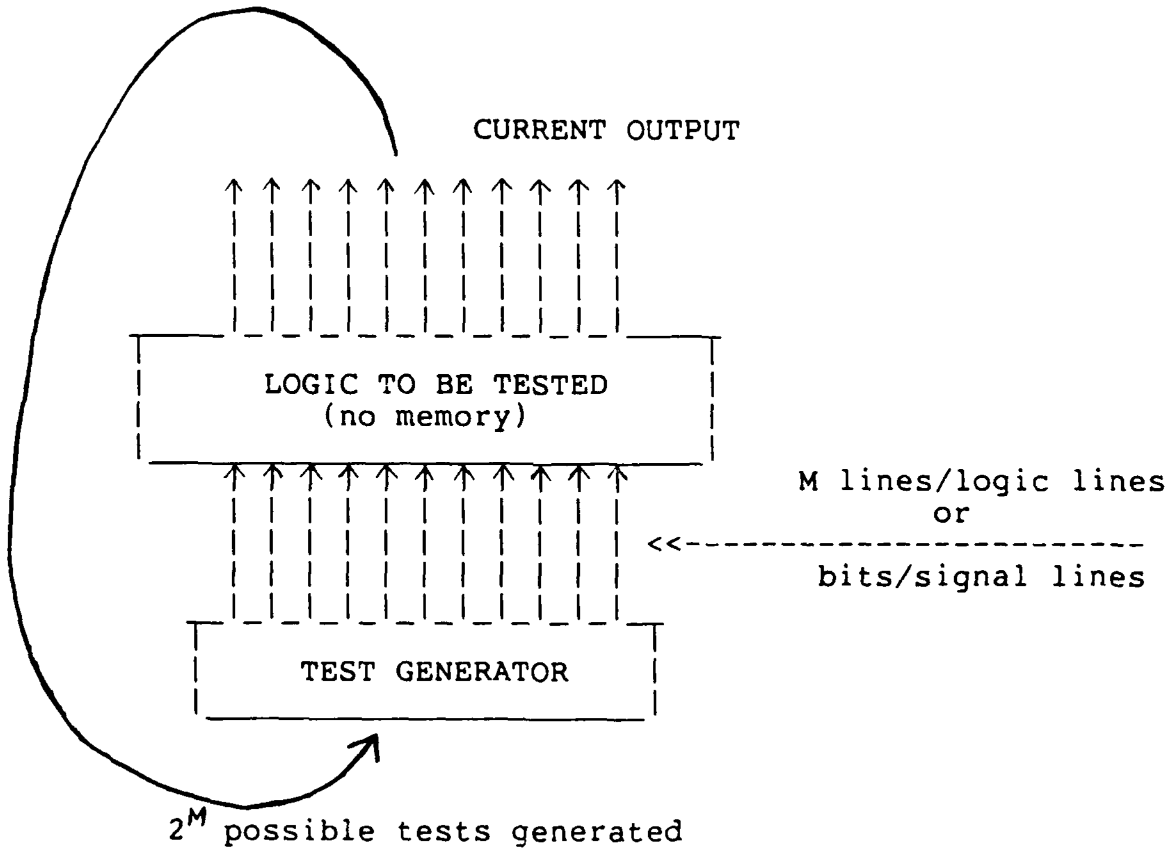
FIG.3
(BIRTHDAY PROBLEM)

PSEUDORANDOM
EXPERIMENT - fake random.



ASSUMPTION: tests are equally probable until the duplicates begin.

FIG.4
(BIRTHDAY PROBLEM)



The logic is combinational, meaning a test will carry useful information only the first time it is applied.

FIG.5

```
EXPONENT (2**exp)                       (2**10)       1000 tests
------------------------------------------------------------------
The 50% mark: n equals:    38        Probability is: 0.5093
The 90% mark: n equals:    68        Probability is: 0.9028
The 99% mark: n equals:    95        Probability is: 0.9901
Probability at  100 =     0.9940
Probability at  200 =     1.0000
Probability at  500 =     1.0000
Probability at 1000 =     1.0000
--- Average =     40.3032

EXPONENT (2**exp)                       (2**13)       9999 tests
------------------------------------------------------------------
The 50% mark: n equals:   119        Probability is: 0.5059
The 90% mark: n equals:   215        Probability is: 0.9015
The 99% mark: n equals:   303        Probability is: 0.9902
Probability at  100 =     0.3915
Probability at  200 =     0.8651
Probability at  500 =     1.0000
Probability at 1000 =     1.0000
--- Average =    125.9929

EXPONENT (2**exp)                       (2**17)      99999 tests
------------------------------------------------------------------
The 50% mark: n equals:   373        Probability is: 0.5008
The 90% mark: n equals:   679        Probability is: 0.9004
The 99% mark: n equals:   959        Probability is: 0.9900
Probability at  100 =     0.0483
Probability at  200 =     0.1806
Probability at  500 =     0.7134
Probability at 1000 =     0.9933
--- Average =    396.9977

EXPONENT (2**exp)                       (2**20)    1000021 tests
------------------------------------------------------------------
The 50% mark: n equals:  1178        Probability is: 0.5002
The 90% mark: n equals:  2146        Probability is: 0.9001
The 99% mark: n equals:  3034        Probability is: 0.9900
Probability at  100 =     0.0049
Probability at  200 =     0.0197
Probability at  500 =     0.1173
Probability at 1000 =     0.3933
--- Average =   1253.9941

EXPONENT (2**exp)                       (2**30) 1073741824 tests
------------------------------------------------------------------
The 50% mark: n equals: 38582        Probability is: 0.5000
The 90% mark: n equals: 70319        Probability is: 0.9000
The 99% mark: n equals: 99446        Probability is: 0.9900
```

FIG.6

RANDOM TEST LENGTH WITH AND WITHOUT REPLACEMENT

*** 1000 experiments
*** 500 tests applied in each experiment
*** 2**18 possible unique tests

tests	experimental E{n}	calculated E{n}	% error
1	1.000	1.000	0.000 %
25	24.998	25.000	-0.008 %
49	48.995	49.00	-0.010 %
73	72.990	73.000	-0.014 %
97	96.980	96.984	-0.005 %
121	120.965	120.984	-0.016 %
145	144.950	144.969	-0.013 %
169	168.939	168.969	-0.018 %
193	192.915	192.953	-0.020 %
217	216.890	216.938	-0.022 %
241	240.868	240.906	-0.016 %
265	264.848	264.891	-0.016 %
289	288.823	288.875	-0.018 %
313	312.791	312.844	-0.017 %
337	336.760	336.828	-0.020 %
361	360.732	360.781	-0.014 %
385	384.711	384.766	-0.014 %
409	408.687	408.719	-0.008 %
433	432.641	432.688	-0.011 %
457	456.597	456.656	-0.013 %
481	480.554	480.609	-0.012 %

FIG. 6, continued

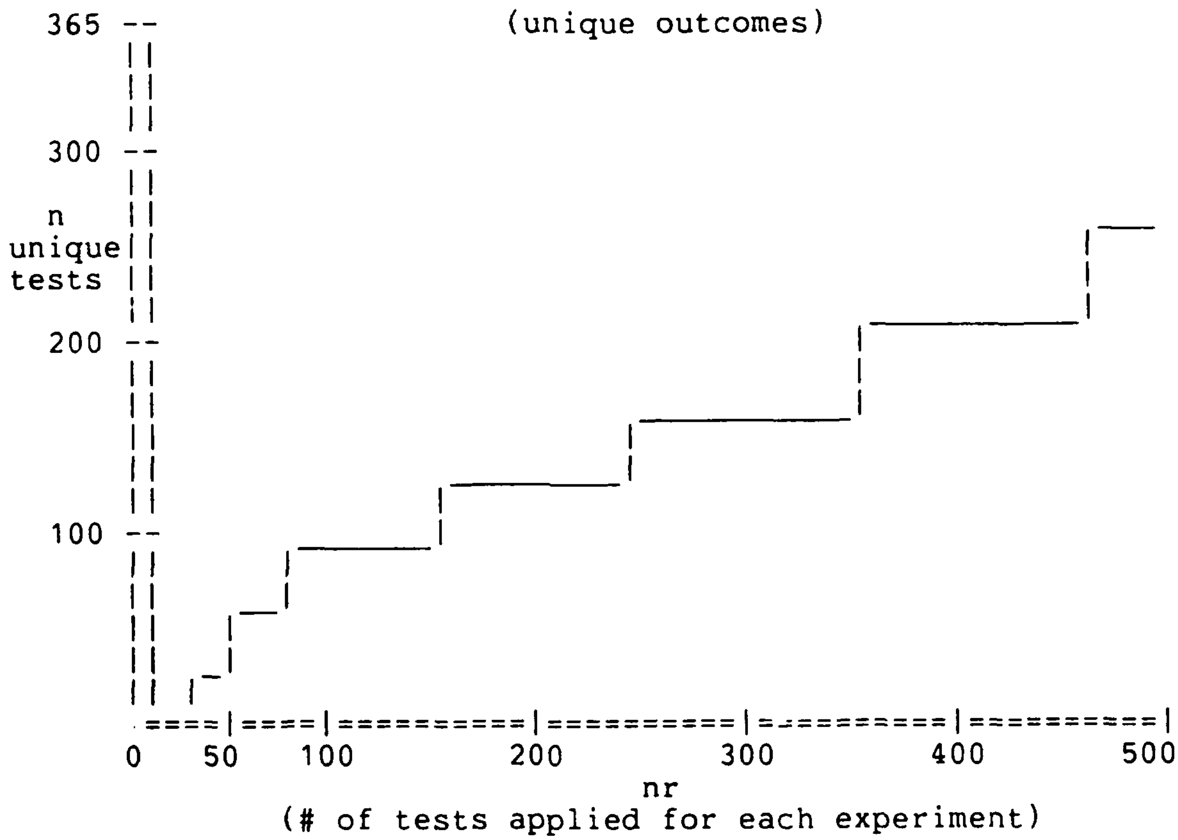


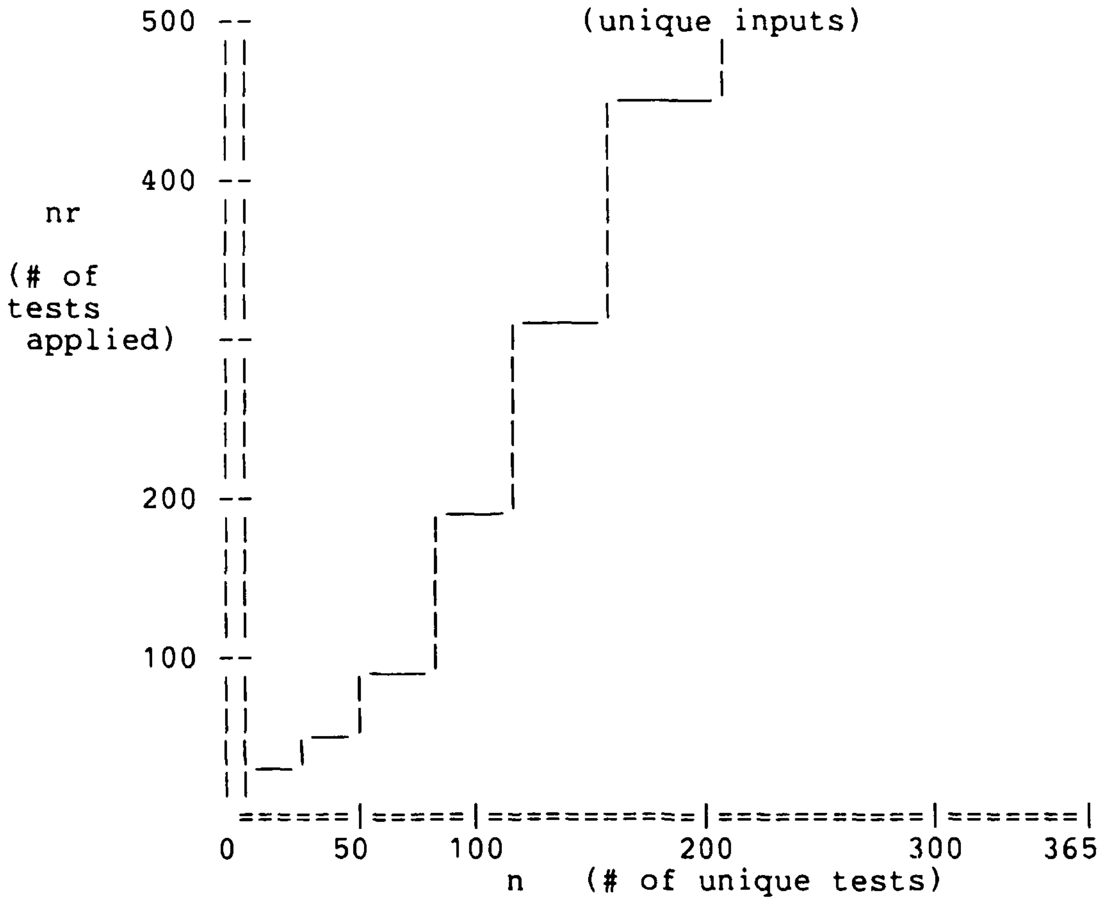
FIG.7

INVERSE

*** 1000 experiments
** 365 possible unique tests

# unique tests	experimental E{nr}	calculated E{nr}	% error
1	1.003	1.000	0.299 %
16	16.366	16.339	0.168 %
31	32.381	32.352	0.091 %
46	49.205	49.100	0.212 %
61	66.738	66.656	0.123 %
76	85.270	85.100	0.200 %
91	104.786	104.527	0.247 %
106	125.447	125.049	0.319 %
121	147.278	146.795	0.329 %
136	170.471	169.921	0.324 %
151	195.161	194.614	0.281 %
166	221.690	221.103	0.266 %
181	250.638	249.668	0.388 %
196	281.362	280.664	0.249 %
211	315.284	314.543	0.236 %
226	353.218	351.896	0.376 %
241	394.385	393.520	0.220 %
256	441.241	440.516	0.165 %
271	494.482	494.481	0.000 %
286	559.644	557.848	0.322 %
301	631.589	634.599	-0.474 %

FIG. 7, continued



STUDENT :

THOMAS SEAN POTTER

MENTOR :

SHARON M. WALTER

TITLE :

PROGRAM ACQUISITION AND MANAGEMENT

DATE :

AUGUST 18, 1989

Acknowledgement

First I would like to thank UES for having the High School Apprenticeship Program and for selecting me as an apprentice. You gave me a chance to work with experienced computer scientists and a chance to make many of new friends. I would like to thank Michael L. McHale, John J. Crowter and James H. Lawton for all the help and guidance they gave me. I would also like to thank Captain Doug Dyer for the help and advice he gave me. Also I would like to thank everyone else who helped me within the Knowledge Engineering Branch at RADC. But I would especially like to thank my mentor Sharon M. Walter not only for her guidance and help but also for taking time from her busy schedule to assist me.

Introduction

The goal of my summer work was to investigate directions of AI research for Computer Assisted Program Acquisition and Management. The reason the people here at RADC want to use AI for Program Acquisition and Management is as follows: (1) The workers here spend a lot of time on paper work. (2) They want a tool that cuts down on the amount of time it takes them to do it. (3) They feel that using AI for Program Acquisition and Management will help them decrease the amount of time it takes. This is why I have been investigating the area.

Part of the problems they will face is the complexity of the over-all project. There are a lot of different forms that must be filled out. Many forms use the same information, so instead of filling out one complete form you may have to fill out two or three. What makes this so complex is there is going to have to be separate code written for every different form. So right away you can see that this is not a easy task.

There are other things that will make the over-all project complex. One is that the personnel is always changing, since there are a lot of military people working here who get transferred quite frequently. Every time someone comes or leaves someone has to change the data. Also, procedures frequently change here so every time they make a new form or get rid of an old one they are going to have to change the code. Additionally, form identification numbers are likely to change periodically, so when they do the code must also be modified.

So you can see that they are going to have a problem developing this program. They will encounter more problems after the program has been written. For example, who is going to change the code when one of the things I have listed above happens? What if the people who wrote the code all leave? Now who is going to keep the program up-to-date? These are real problems that will be faced with this project and these problems will make the project complicated.

Related Work

Part of my time here at RADC was spent researching to see what other people were doing in the area of Program Acquisition and Management. I did a literature search to see what people were doing in that area. What I found was that a lot of people were working on projects using AI. I also noticed, through the literature search, that people were doing some similar work in the area of Program Acquisition and Management.

One of the organizations we (my mentor and I) contacted sent us a response but it really did not delve into the specifics of their work. They told us that they had been working on CORT Expert System Aid for over a year. CORT Expert System Aid is an expert system prototype for aiding the ARO/CORT in answering contract pre-award area questions. They are implementing it for the IBM PC using Exsys Professional. Right now it has a little over 200 rules and it has been shown to a small group of people.

We have also contacted another organization but they have not replied to our letter. We do have some brief information on their project. Their objective is to merge Knowledge Based Systems with a personal computer work station. This will provide expert assistance for software system acquisition managers, which will improve the quality of decisions and assure that the major issues are properly addressed. Their approach is to use a Knowledge Based Expert System, which will demonstrate the implementation of a small portion of an acquisition Knowledge Base.

My Investigations

Since I started working at RADC this summer I have spent most of my time investigating different packages for developing a Program Acquisition and Management system. For one of the packages that I investigated I had to become familiar with Prolog and Emacs. To familiarize myself with Prolog I went through a tutorial and a book on Prolog. To learn Emacs I went through a computer-based tutorial. I have also worked on the Macintosh II, since it is a flexible computer and Sharon (my mentor) thought that it would be beneficial to me to learn how to use it.

The first software package that I investigated was VP-Expert made by Paperback Software. VP-Expert is a shell for building Expert Systems. To become familiar with VP-Expert I went through the VP-Expert Rule Based Expert System Development Tool manual, which had many chapters with hands-on exercises in them. The manual included a sample disk with many examples of what the capabilities of VP-Expert were. I spent over a week on the manual and exercises; however, when I tried to write my own program with VP-Expert I had many problems. One problem I encountered was that no one in the branch had ever used VP-Expert before, so when I got an error that I did not understand no one was able to help me. Another problem I had was that VP-Expert and another piece of software on the hard drive were interacting with each other, which caused many internal problems. We thought that this was why my program would not run. So I moved to another computer and it still would not run. So you could say that I was not too successful with

VP-Expert. If the people here at RADC decide to use this piece of software I hope they have much better luck with it than I did.

The next software package that I investigated was HyperBase by Cogent Software, Ltd. HyperBase is a computerized documentation system. Before I could explore HyperBase I had to learn Prolog because HyperBase uses Prolog. I went through the tutorial that came with the package; this introduced me to the basics of HyperBase but it did not give me a detailed account of it. When I started to go through the HyperBase manual I learned that it did not come with an editor. So I had to learn how to use one and the one I picked was Emacs. I chose to learn Emacs because it is frequently used here. Once I knew how to use Emacs I finished reading the manual on HyperBase. After I did that I went through the sample disk that came with the package.

Now that I was familiar with HyperBase I was ready to program. It was about time. I had spent almost three weeks learning about the systems and now I was finally ready to program. I told Sharon that I was ready to program. She gave me an AFSC Form 2916 and told me to try to get enough code done so we could give a demo on it. So I started working on it, and of course, I ran into some problems. Luckily for me someone here had used this package before and was able to help me when I ran into these problems. I had parts of my project running but I did not have enough time to finish writing it.

A few days before the end of my work here at RADC I found a piece of software that might be just what the people here are looking for. The piece of software is SmartForm Series by Claris for the Macintosh. There are two SmartForms, SmartForm Designer and SmartForm Assistant. SmartForm Designer is the advanced tool specifically created to design professional-quality forms quickly. The second one is SmartForm Assistant. SmartForm Assistant is a convenient tool for completing electronic forms quickly and accurately. This piece of software has the ability to create forms which will help you fill them out. Unfortunately I did not get a chance to check this piece of software out. The reason being was the people here at RADC had not received this piece of software yet.

Since I have been here I have used three different types of computers. The first one I used was an IBM PC, which is what VP-Expert and HyperBase run on. The second was the Macintosh II, the machine I am using to do my report on, and the machine on which SmartForm Series runs on. The third and last machine I worked on was the Symbolics computer. Symbolics machines are Lisp machines that Sharon thought I should learn how to use. So for a few days when Sharon was on TDY I went through a manual that had many exercises in it. This gave me basic information on Lisp but did not get into the specifics of the language.

Conclusion

In conclusion of my paper and my work here at RADC I will leave you my suggestion for the over-all project. I feel that you should forget about using the PC and think about using the Macintosh. The "Mac" has many great features that the PC just does not have: (1) The window system allows you to open multiple workspaces. (2) Icons make opening files easy. (3) The mouse lets you move around the screen easily which allows you to make changes to documentations easier. (4) The "Mac" is easy to learn how to use. (5) The "Mac" is very user friendly. (6) The "Mac" has a software package specifically designed for form filling. Another reason I think they should use the "Mac" is that everyone in the branch will have one soon so they will be easily accessible. With all of this going for the "Mac" don't you think it would be a smart choice to use it?

This is everything that I have done since I have been here at RADC. I would like to take this time to thank everyone again I had a lot of fun and I would like to come back next year. It was a valuable learning experience and a chance to make new friends.

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Error Injector Unit Project
Testing Programs

Student:Richmond A. Real
Mentor:John M. Colombi
August 14, 1989
RADC/DCLD

Acknowledgements

I would like to thank Christine Harrison for introducing me to the Error Injector Unit project and the RADC personell and environment. I would like to thank James Grinnell, Mark Rose, and Christine Harrison for their help in C programming. I would also like to thank Paul Kasper for teaching me somthing about hardware, and for his skill in building the circuitry we needed. Lastly, I would like to thank John Colombi for accepting me on this project, and John Evanowsky for his able management of the project as a whole.

1.0 Introduction

This report concerns the Error Injector Unit (EIU) Project. The RADC/DCLD network lab is simultaneously working on two major projects at once. Both are related. One project is Romenet. This project concerns the design of a file transfer protocol. The EIU project that this report is concerned with is designed to be interfaced with Romenet, and will simulate extreme stress on the system. The EIU project consists of a computer hooked up to a Random Number Generator (RNG) circuit, an EIU circuit, a clock, and a line to a "network controller" that will alter the simulated conditions. The computer continuously checks for either the new conditions, or a clock tick. Once it receives a clock tick, it then reads a random number, uses that number to decide if the output running through the EIU is "good" or "bad". It tells the EIU circuit the decision, and the hardware then injects the error, if any. Meanwhile, the computer goes back to watching for updated instructions or a clock tick.

1.1 Hardware

There were two formats the hardware could take. The first had the RNG placed directly on an AT prototype board, and placed on a 386 motherboard. The EIU is external to the computer and plugs into it. Access to the RNG is by direct addressing. The other version has the EIU and RNG both external to the computer, and plug into a DT2817 Data Translation Digital I/O card. This version also requires the use of the LPCLAB SP0159 device driver to user the card. Both versions have been developed. The prototype card is preferable, however, due to snags in its development, the I/O card configuration has been developed to completion, in order to provide a working model of the whole EIU.

This report mostly concerns the testing of the hardware aspects of the project, before assembly as a whole. The hardware test programs are all written in Microsoft C. The one software test program was written in GW-BASIC, and it reads the data produced by the original test program, designed as a simulation of the EIU to see if it was feasible. Each of the sections that follow concerning the actual work have details of that section explained there.

1.2 Significance

The project, as a whole, does have significance, as it, in part, simulates the effects on military communications of hazardous environments. As Griffiss AFB is a SAC base, it is important to know the effects of a limited nuclear war on our communications system.

2.0 Test Programs for the Error Injector Unit (EIU) Project

2.1 Hardware Test Programs

There are two main types of hardware test programs, programs that test the Data Translation DT2817 Digital I/O (Input/Output) EIU configuration, and programs that test the prototype board EIU configuration. Each type will be described in its own section. Those programs that deal with the I/O card have the file name [xxxx]io.c and prototype card programs are called [xxxx]prot.c.

2.1.1 Digital I/O card EIU configuration

The components of this set-up are a Data Translation DT2817 Digital I/O card, a clock of some kind, the LPCLAB device driver, and the board with the EIU and the Random Number Generator (RNG). The DT2817 I/O card has 4 8-bit ports. Port 0 is dedicated to the EIU. Port 1 receives clock input. Ports 2 and 3 receive 8 bit random numbers from the RNG. The clock is optional for most test programs, and consists of any device than can generate a regular series of pulses. The LPCLAB I/O device driver must be installed in the computer. It provides for the specialized commands needed to initialize and use the DT2817 I/O card. Procedures for installation are found in the LPCLAB SP0159 User Manual. The board with the EIU and RNG circuit is a large, external board with a separate power source wired to a connector that fits the DT2817 interface.

2.1.2 Digital I/O card test programs

All I/O programs are in appendix A. All these programs must be compiled using Microsoft Optimizing Compiler (MOC). The programs must be linked with LPCLCS in order for the computer to understand the specialized functions used with this card. The precise command is:

```
cl [filename] /link lpclcs
```

This will create an executable file that can then be run by typing the filename.

2.1.2.1 SHIFTIO.C

This program was created to discover the exact format to turn 4 8-bit reads into 1 32 bit number. The noteworthy aspect of this program is the variable declaration 'unsigned long int', which is not a normal C statement. However, it is the only way the program will shift the numbers correctly.

2.1.2.2 ALTIO.C

One problem that has plagued the hardware aspects of the EIU project is the inability to "see" what is happening with the system, since it is not hooked in to anything, and therefore generates no results. This program sends a pulse to the EIU every other time the program receives a tick from the clock. This program discovered that the pulses generated by the program lagged far behind the clock pulses, when the system was examined using an oscilloscope. This proved that the I/O card slowed the passage of data by a rate so great that an actual finished product of the EIU must be based on the prototype card. The I/O card is only suitable for a prototype and to test the EIU and RNG circuitry.

2.1.2.3 RNGIO.C

This is another of the "simple" test programs. All this program does is read all 4 ports and print what the computer finds to screen. This program did find several basic problems however, including the fact that the wiring had broke free twice, and that the original soldering job assigned jobs to the wrong ports. It also assisted in refining SHIFTIO.C.

2.1.2.4 SORTIO.C

SORTIO.C is one of the more complex test programs. It reads the ransom number generator 4 times, combines the reads into 1 32-bit number, repeats this approximately 165 times per second, up to the number of times the user desires (the maximum on this is 4,294,967,296 ,more than enough for any normal use). Each number during the run is divided by 100 million and the result is the number in an array that gets incremented. The array is displayed as a graph at the end of the run. The purpose of this program is to find out if any bias exists in the numbers the random number generator creates. While no very long test run has been done yet, the program has been run several times at intervals of 1 hour and less, and no bias was found.

2.1.2.5 TIMEIO.C

This program does the same as SORTIO.C, but for a user set time instead of a set number of reads. The user inputs the number of hours wanted, hits 'ENTER', the number of minutes, hits 'ENTER', and the number of seconds. The maximum number of days the program can run at the speed it has is 75. As this is extremely high, there should be no worries. Other than this, the program is identical to SORTIO.C.

2.1.3 Prototype Board EIU Configuration

The prototype board configuration is more compact than the I/O board configuration. The RNG is contained on an AT prototype board designed to plug directly into the AT 386 motherboard. The EIU is contained in a separate circuit that plugs into the computer. No software driver is required, and no library files must be linked.

2.1.4 Prototype board test programs

All prototype board test programs require that the address of the prototype board be included in the program in a #define statement. All programs tell which #define contains the address of the prototype board. The reason there are less test programs for the prototype board arrangement is that the prototype board was still at the stage of figuring out how to access it successfully and get true random numbers from it. Therefore, all the more "advanced" programs were never needed.

2.1.4.1 READPROT.C

All this program was designed to do is to provide constant access to the RNG circuit on the prototype card. This provided activity that could be measured on an oscilloscope, and activity that abnormal could be found and corrected. Using this program, the problems with the card could be traced to the addressing arrangements, however, it could not be any more specific.

2.1.4.2 TESTPROT.C

Testprot is virtually identical to READPROT.C. However, Testprot only gives a number when requested. This makes the reading of individual pulses possible, distinguishing them from other types of activity.

2.1.4.3 ALTPROT.C

Altprot sends an alternating bit to the EIU to test its circuitry. This program accomplishes virtually the same thing as altio, but it is designed around the different hardware arrangement. Since the EIU expects to receive a series of ones and zeros from the EIU software, this program simply has the effect of "activating" the EIU so it can be tested using an oscilloscope.

2.1.4.4 SORTPROT.C

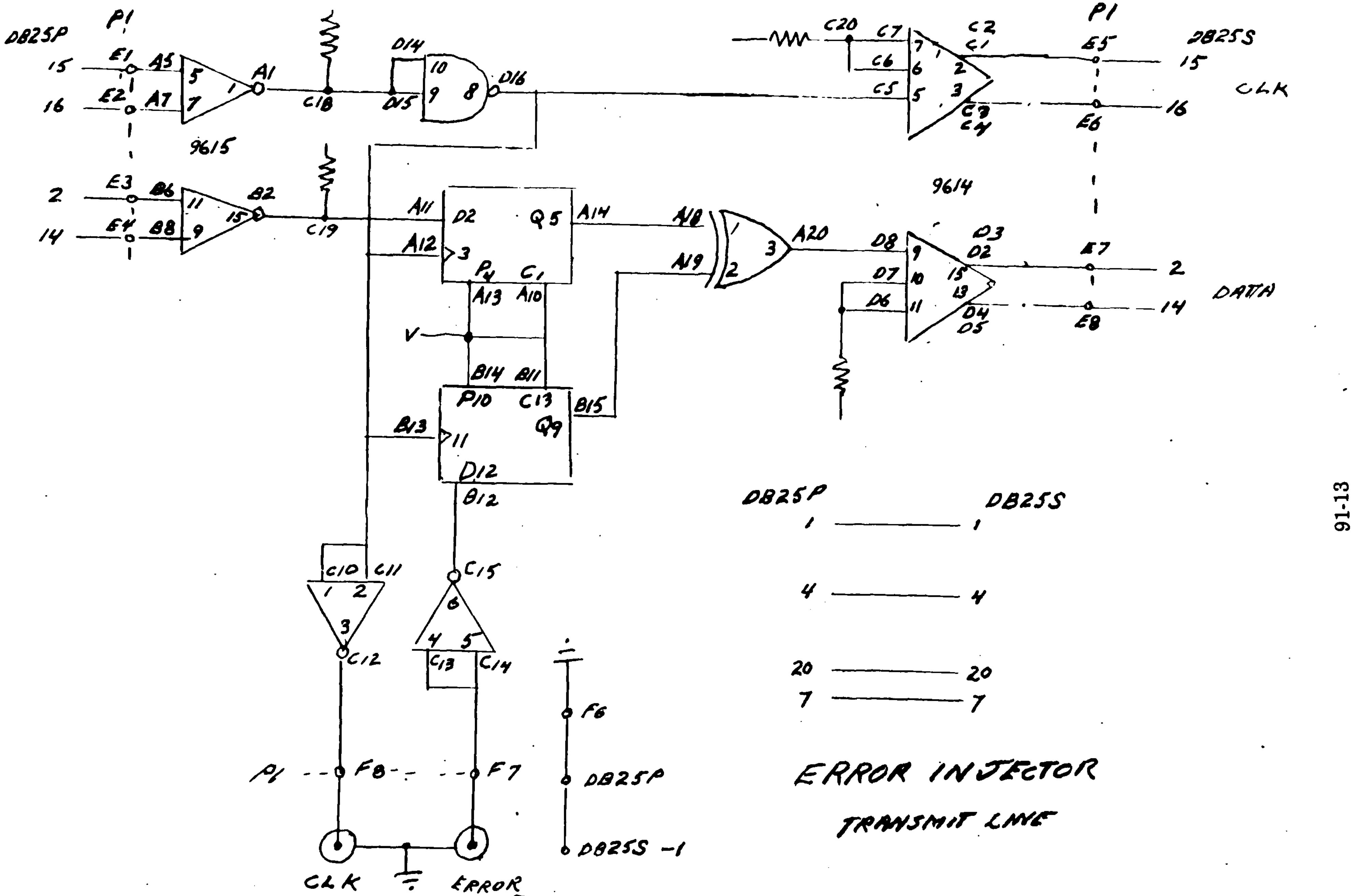
Sortprot.c is the program for the prototype board that reads a user-given number of numbers and then sorts them into the same categories SORTIO.C does. This program's largest flaw is that it has never been run. Since work on the prototype card never reached the stage of getting workable random numbers, this program was never used. Consequently, it has never been debugged. It is documented extensively to make tracing it simple.

2.2 Software Testing Programs

The only program that falls into this category is DATAREAD.BAS. This program was designed to read the data produced by the EIU_TEST program designed by Christine Harrison. It can organize the data into 4 formats. One is to print the number of errors in a given block size. Another is to print that graph out to the printer. It is also possible to print out a graph of one or two datafiles at once in graphics mode. These formats organize the data in a usable way, to see if the data agrees with what should be coming out. This program has nut be used with data generated with the RNG yet. All previous runs used data from a "pseudo-random" number generator, and so were not accurate runs. However, using the data received using the pseudo random numbers the error pattern is about what should be expected.

3.0 Hardware

On this project, while both types of EIU types were being made, I had to spend time in the technical lab making the circuitry for the EIU while the technicians there worked on fixing the prototype card. The circuit itself was made by wire wrapping on an empty board, and the chips themselves were plugged into the other side. Included on the next two pages are schematics of the circuitry constructed.



ERROR INJECTOR

TRANSMIT LINE

SINGLE CHANNEL

CHASSI

1 OF 2

Apprendices can be obtained from

Universal Energy Systems, Inc.

TEST PLAN FOR THE EVALUTAION OF
ADVANCED SECTOR OPERATIONS CONTROL
CENTER (SOCC) WORKSTATIONS
(PRDA 89-4)

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DAYTON, OHIO 45432

FOREWORD

The author wishes to express his appreciation to the Air Force Office of Scientific Research for providing excellent facilities for research, and Universal Energy Systems for providing the opportunity. Thanks also goes to Robert Ragazzo, of RADC/COAA, for his ideas and support, and Lt. John Taylor Selden II for his advice. Special thanks goes to Neil Marples, of RADC/COAA, for his constant input and support throughout the summer.

SECTION I

INTRODUCTION

1. SCOPE

This report covers a basic tentative testing procedure and evaluation of the hardware/software systems for an upgraded ADI surveillance workstation made by Titan Systems, Inc.; SRI International Systems; CONTEL Federal Systems; Advanced Programming Concepts, Inc.; Lockheed Missiles and Space Company; Grumman Aircraft Systems; GENISYS Research and Development; UFA; and Hughes Large Screen Display Effort.

2. PURPOSE

The purpose of the testing is to determine the most efficient and modern system for ADI surveillance that falls under Air Force requirements for a Sector Operations Control Center (SOCC) using "Off the shelf" equipment.

3. BACKGROUND

The Air Defense Initiative (ADI) Surveillance, I.D., and Weapons Control workstation as proposed by nine companies to augment and improve current Sector Operations Control Center (SOCC) / ADI functional capabilities.

From 74 white papers responding to a request for an improved SOCC sent out by RADC/COAA, 26 were chosen as preliminary choices, and then nine were ultimately chosen to concentrate on and make contract with. Of these nine, one must be chosen to demonstrate enabling technology.

SECTION II

TEST PROGRAM

1. LOCATION

Testing of the nine proposals is to take place at the RADC Command and Control Technology Lab (C^2TL) located on Griffiss Air Force base in Rome, New York.

2. SYSTEM DESCRIPTION

TITAN Systems, Inc: The TITAN workstation consists of a SUN workstation plus five software packages: ISR's ISR-MAP system, TITANs CUTM and KBEST systems, the ORACLE data base management system, and a GDS communications formatter module. TITAN plans to integrate the hardware and software to represent computer graphics, human-machine interface designs/techniques, and communications interfaces.

For computer graphics, maps and display system technology (ISR-MAP) will be applied to graphic representation of digital maps, terrain and topographic data, vertical obstructions and other features along with real-time overlays of track, flight plan and relevant status data. Multiple windows for text, graphics, photos, and video; Zoom-level selection, lat/long coordinate display, and distance computations; Inset maps, quad-map displays, and map swapping; Real-time tracking of multiple icons; flight and movement animation; Automatic zoom/pan capability based on flight speed, altitude, location, etc.; and Very high-resolution graphics and draw rates are included in this technology.

The TITAN workstation is capable of surveillance and monitoring of flights, identification, target recognition, weapons assignment and control of interceptors, and other major air defense mission functions. Also, by using KBEST, "smart" recommendations can be made concerning airborne threats, the environment, and air defense system capabilities and status.

SRI International: The SRI workstation is also composed of a Sun workstation and software created by SRI. Their concentration is on sorting out the great amounts of data that a workstation operator must evaluate manually. They have some capability for identification and weapons control but it seems their greatest concern is on surveillance. "Smart" recommendations are also a part of SRIs workstation, but to a much lesser degree than TITAN.

Grumman Aircraft Systems: The Grumman workstation uses a Harris RTX2000 Development System, based on the NOVIX RISC technology. The Grumman system can handle Surveillance capabilities very well. They are also capable of Identification and Weapons Control management, but like SRI, their concentration is on surveillance.

Advanced Programming Concepts, Inc.: The APC workstation is composed of an Intel 32-bit IBM PC compatible microprocessor linked to other workstations via the Ethernet LAN system. Identification and Weapons control are little to no concern of APCs, yet, like SRI and Grumman, their surveillance system is highly developed.

Lockheed Missiles and Space Company, Inc.: Lockheed's workstation uses a Digital Equipment Corporation (DEC) MicroVAX III processor. The ADEWs (Air Defense Enhanced Workstation) are linked to the MicroVAX III and other workstations via the Ethernet LAN system. Lockheed's proposal concentrates on all three basic ADI concerns: Surveillance, Identification, and Weapons Control Management. Lockheed's system also incorporates "smart" recommendations concerning situational stimuli.

UFA, Inc.: The UFA system is comprised of an Apollo 10000 processing unit (equivalent to four CPUs), Apollo 3500 workstations, and Apollo 3000 workstations. The UFA system is capable of Surveillance, Identification, and Weapons Control Management, as well as "smart" recommendations.

CONTEL Federal Systems: The CONTEL workstation is composed of a single Ops/Intel workstation that can be used to support any of the six unique user functions in the USCS C3I system. In the past, the CONTEL system was used to support Custom's unique drug-smuggler interdiction mission. Users consist of shift supervisors, intelligence analysts, and detection system specialists supporting either the air or maritime smuggler interdiction efforts. This sort of previous use can easily be used in an ADI system and have applications in the SOCC. Through this past usage, Surveillance and Identification operations can easily be achieved.

GENISYS Research and Development: The GENISYS proposal incorporates an Intel 80386-based host for their processing unit. For soft ware, GENISYS proposes using Microsoft's "C". The GENISYS system can handle Weapons Control and Allocation. Surveillance operations and Identification operations are not concerns of the GENISYS proposal.

3. SCHEDULE

The schedule outlined below is that of the testing periods given in the technical manuals of each proposal. For concentration purposes and to implement the Hughes Large Screen Display Effort in monitoring the other eight proposals, the schedule on the following page will be used.

Company	Weeks after Contract Award		
	Begin	End	Duration
TITAN Systems, Inc.	20	24	4
SRI International Systems	28	32	4
Grumman Aircraft Systems	22	24	2
Advanced Programming Concepts, Inc.	not specified	not specified	not specified
Lockheed Missiles and Space Company	21	23	2
UFA, Inc.	18	32	14
GENISYS Research and Development	26 & 30	28 & 32	2+2
CONTEL Federal Systems	16	20	4
Hughes Large Screen Display Effort			8

The following schedule table is to incorporate the Hughes Large Screen Display Effort. Hughes will be at the RADC/C^2TL for a total of eight weeks. During that period, two ADI simulator proposals will be tested simultaneously for two weeks using the Hughes Large Screen Display Effort as a monitor.

Week	Company
One } Two	GENISYS Research and Development UFA, Inc.
Three } Four	Lockheed Missiles and Space Company Advanced Programming Concepts, Inc.
Five } Six	CONTEL Federal Systems Grumman Aircraft Systems
Seven } Eight	SRI International Systems TITAN Systems, Inc.

SECTION III

TESTS CONDUCTED

1. SYSTEM DEMONSTRATION

At some point after the date of contract awarding, the nine companies will visit RADC and demonstrate their workstation capabilities in their own fashion. Immediately following these demonstrations, testing of the systems will commence by RADC employees.

2. INTERFACE

Some companies have requested live JSS radar track data to demonstrate their workstation. Provisions will be made to interface their system to whatever data they require (via radio, fiberoptic cables, or Ethernet.)

The Hughes Large Screen Display Effort will also be incorporated into systems for ease of viewing and evaluation of the Hughes Large Screen Display Effort proposal.

3. EVALUATION

Evaluation of the proposed systems, in this testing procedure manual, revolves around the appendix found at the end of this document. The appendix is in a data-sheet form made for ease of evaluation of the system at hand. One data-sheet should be completed and filled out by each evaluator for each separate workstation.

The criteria for evaluation are as follows with explanations for each and what should be placed under the appropriate blank on the data-sheet. Criteria may also be found in the appendix under respective numerals.

1. MAXIMUM NUMBER OF SIMULTANEOUSLY TRACKED TARGETS: This number is the maximum amount of targets the system can track, simultaneously, at one certain time. No units.

2. MAXIMUM AREA OF TRACKING: This data is the maximum area range the system can track. Although radar (most likely JSS) are the major factors in this criterion (and their range covers the entire US airspace), the system must be able to correlate all the incoming data and process it; the number will be a representation of two things: 1. practical surveillance range, and 2. extent of processing capability. Units are in square nautical miles.

3. MINIMUM AREA OF TRACKING: This numerical data is the minimum area range the system can track. It shows to what extent the system can pinpoint events and targets. Units are in square nautical miles.

4. MAXIMUM ALTITUDE FOR TRACKING: To what altitude can the system track a target. This data, like Criterion 2, shows to what extent the system can correlate data and process it and is largely dependent on radar capabilities. Units are in feet.

5. MAXIMUM VELOCITY FOR TRACKING: What is the maximum speed a target can travel before tracking becomes impossible? This also details the processing speed of the system. Units are in miles per hour.

6. MINIMUM DATA TRANSMISSION AND PROCESSING TIME: This number is the minimum time required for data, transmitted from radar, to be received and processed. Units are in seconds.

7. MINIMUM TARGET CROSSECTION: To distinguish between cruise missiles, fighter jets, passenger jets, and the like, radar should be able to determine identity by crossectional area. The number should be the minimum crossectional area that the system can distinguish and identify. Units measured in square feet.

8. CLASSIFICATION CAPABILITIES (IDENTIFICATION): This covers how well the system identifies targets.

a. Timeliness: On a rating of one to ten (ten being best), how timely is identification. Relates to Criterion 6.

b. Accuracy: Also on a rating of one to ten, how accurate is identification.

9. THREAT EVALUATION/DETERMINATION: Does the system evaluate threat status for tracked targets or is does the system rely on manual evaluation of targets. "Yes" means the system has automatic threat evaluation; "no" means the system uses manual evaluation. The ability to toggle automatic threat evaluation on and off is a "yes" answer.

10. INPUT/OUTPUT COMPATABILITY: For each of the following, does the system allow interface with?

a. E-3 Input/Output (TADIL-A Comm)

b. OTH-B radar tracks.

c. Positional information for SCLM capable subs.

d. JSS radar data and tracks.

e. SBR track data.

f. Flight plan data.

g. INTEL.

h. Other______________________

11. "SMART" RECOMMENDATIONS: Based on the responses to the following, rate the ability of the system to make "smart" recommendations on a rating of one to ten (ten always being highest).

a. Flight path from origin: Does the system allow for a graphic and/or text representation of the targets flight path from origin (as long as the data is available)?

b. Predicted flight path: Does the system allow for a graphic and/or text representation of the targets flight path in the near future (for interception purposes)?

c. Predicted target mission goals: Based on flight path and similar data, can the system predict what the target's goal is?

d. Radar fusion: Can the system determine which radar data is most reliable? Factors that may make radar data unreliable can be weather situations, jamming, and similar hindrances.

e. Weapons allocation/direction/control: Can the system suggest methods of weapons allocation, direction, and control to efficiently and effectively deal with events?

12. TERRAIN AND TOPOGRAPHIC DATA: Can the system incorporate topographic data into graphic and/or text representation?

13. GEOPOLITICAL BOUNDARIES: Can the system incorporate data concerning geopolitical boundaries into graphic and/or text representation?

14. WEATHER EVALUATION: On a rating of one to ten, ten being the best possible rating, how well does the system evaluate weather conditions or hazards?

15. GRAPHICS: Again on a rating of one to ten, how advanced are graphic representations of the area monitored?

16. TABULAR DISPLAY: Does the system have a tabular display method?

17. USER FRIENDLY (Icon menu, Mouse, etc.) On a rating of one to ten, ten being very easy, how easy is the system to use and understand?

18. COMMUNICATION NETWORKING: On a rating of one to ten, how well does the system network workstations, i.e. how well does the system link weapons workstations to identification workstations to surveillance workstations.

19. MOBILITY: On a rating of one to ten, how well can the system be transported and ruggedized to operate in the field?

20. RECONFIGURABILITY: How well, on a rating of one to ten, can the system be updated, enhanced, and linked to other systems?

21. ICON/SYMBOL APPROPRIATENESS: Related to Criterion 17, how well do the icons or symbols pertain to the object at hand on a rating of one to ten? I.e. Is it simple to tell that the icon of a threatening target is a threatening target, or do tables need to be consulted to determine the exact nature of the icon? For example, is the threatening target a red triangle and friendly targets blue or white triangles?

22. TOGGLE FUNCTIONS (accomplished via:______________________): In the blank, fill in the method by which toggle functions are accomplished (switches, Mouse, etc.). Then rate, on a scale of one to ten, how well the toggle functions work.

23. COLOR MONITOR: Due to the past SOCC workstations, color monitors have become a relatively important part of the evaluation (seeing that the old workstations have monochromatic green monitors). The rating of one to ten, ten being best, determines to what ease the monitors may be viewed for long periods of time (the same principle as yellow paper being less taxing on your eyes than white paper.)

SOCC WORKSTATION EVALUATION SHEET

Proposal From: ______________________

1. Maximum Number of Simultaneously Tracked Targets.... __________

2. Maximum Area of Tracking.............................. __________ Nm^2

3. Minimum Area of Tracking.............................. __________ Nm^2

4. Maximum Altitude for Tracking......................... __________ ft

5. Maximum Velocity for Tracking......................... __________ mph

6. Minimum Data Transmission and Processing Time....... __________ sec

7. Minimum Target Crossection............................ __________ ft

8. Classification Capabilities (Identification)
   a. Timeliness.................................(1-10) __________
   b. Accuracy...................................(1-10) __________

9. Threat Evaluation/Determination..................(yes/no) __________

10. Input/Output Compatability
    a. E-3 Input/Output (TADIL-A Comm)...........(yes/no) __________
    b. OTH-B Radar Tracks........................(yes/no) __________
    c. Positional Info for SCLM Capable Subs.....(yes/no) __________
    d. JSS Radar Data and Tracks.................(yes/no) __________
    e. SBR Track Data............................(yes/no) __________
    f. Flight Plan Data..........................(yes/no) __________
    g. INTEL.....................................(yes/no) __________
    h. Other ______________________________ ....(yes/no) __________

11. "Smart" Recommendations............................(1-10) __________
    a. Flight Path From Origin...................(yes/no) __________
    b. Predicted Flight Path.....................(yes/no) __________
    c. Predicted Target Mission Goals............(yes/no) __________
    d. Radar Fusion (data from one radar being more reliable than another).......(yes/no) __________
    e. Weapons Allocation/Direction/Control......(yes/no) __________

12. Terrain and Topographic Data.....................(yes/no) __________

13. Geopolitical Boundaries..........................(yes/no) __________

14. Weather Evaluation.................................(1-10) __________

15. Graphics...(1-10) __________

16. Tabular Display..................................(yes/no) __________

17. User Friendly (Icon menu, Mouse, etc.).............(1-10) __________

18. Communication Networking...........................(1-10) __________

19. Mobility...(1-10) __________

20. Reconfigurability..................................(1-10) __________

21. Icon/Symbol Appropriateness........................(1-10) __________

22. Toggle Functions (accomplished via: ______________)..(1-10) __________

23. Color Monitor....................................(yes/no) __________

ANALOG

OPTICAL PROCESSING

EXPERIMENTS

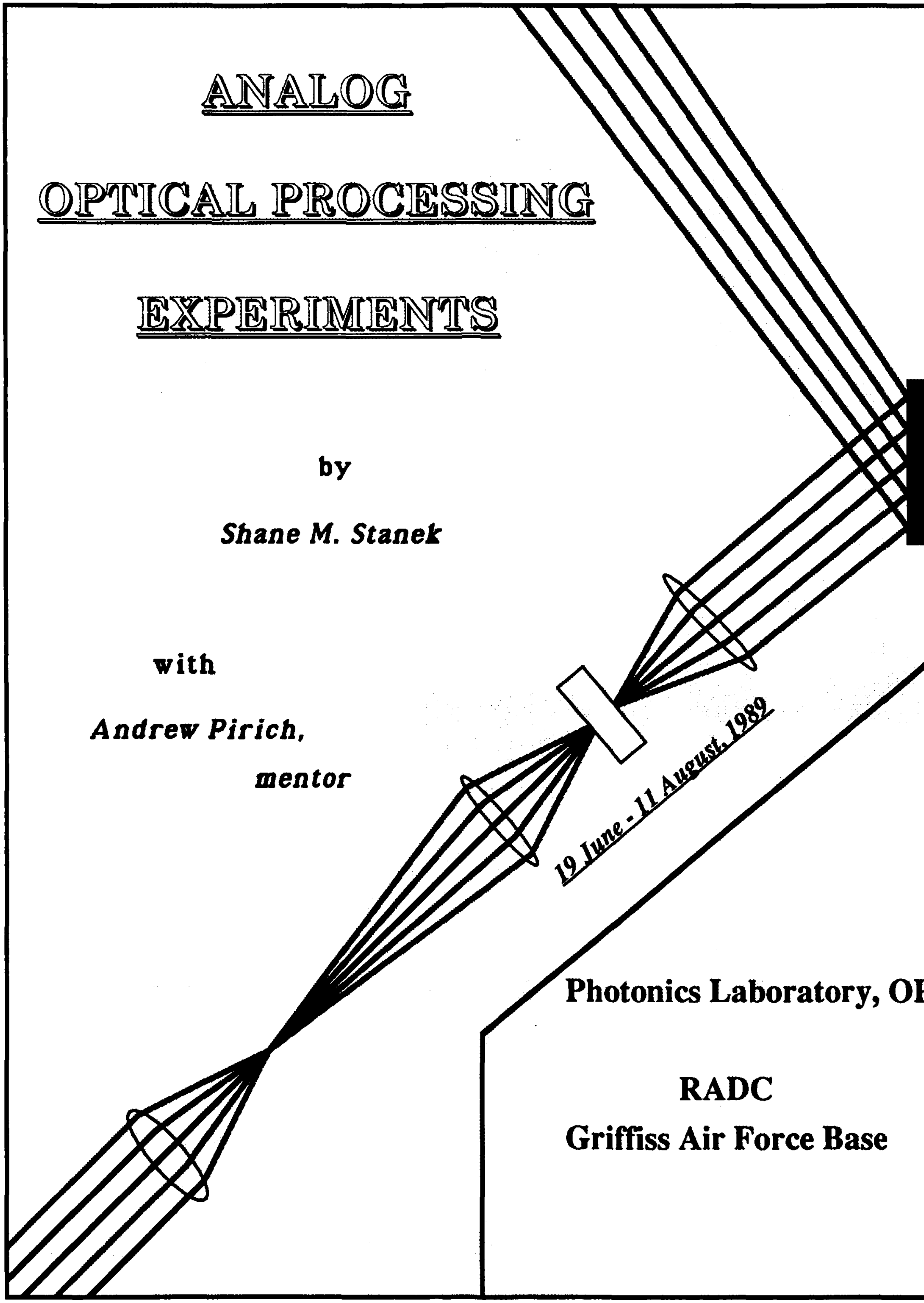
by

Shane M. Stanek

with

Andrew Pirich,

mentor



19 June - 11 August, 1989

Photonics Laboratory, OPA

RADC

Griffiss Air Force Base

INTRODUCTION

During the eight weeks from June 19 to August 11 1989, I was a part of the High School Apprenticeship Program sponsored by Universal Energy Systems and the Air Force Office of Scientific Research. The internship took place at the Photonics Laboratory, Analog Optical Processing Branch, Rome Air Development Center, Griffiss Air Force Base, New York. My mentor during this time was Mr. Andrew Pirich, and I worked with many others to gain a well-rounded understanding of the technology.

I. THE "AIRPLANE DEMO"

The first project was the optical setup of the "The Airplane Demo", which demonstrated the basic concepts of analog optical processing. The system consisted of a five milliwatt Helium-Neon laser generating a red beam, passing through a collimator. The light then passes through two superimposed slides, each containing the image of an airplane. The first is an F-16 made with horizontal stripes, and the other a MiG of vertical stripes. Next, the "beam" passes through a lens, which produces a Fourier Transform, a "cross-shaped" pattern representing the image. The "cross-shaped" pattern is passed through a "mechanical" filter containing a slit.

When the filter (slit) is lined up with the appropriate stripes, and is projected on a screen, the corresponding aircraft is seen. Figure 1 is a representation of this optical system.

II. THE OPTICAL PROCESSOR

One of the technical tasks of the Optical Processor project was to evaluate the use of a liquid crystal television as a one-dimensional spatial light modulator (SLM) for adaptive signal processing.

The scenario, which follows, is shown in Figure 2. A signal s(t), that we wish to determine is received by the main antenna. Also being received is a noise signal n(t) . The sum is denoted by d(t). The omni-directional antenna receives just noise, $n_1(t)$, which consists of delayed versions of n(t). This information is used to determine y(t), as shown in Figure 3. Weight information is updated

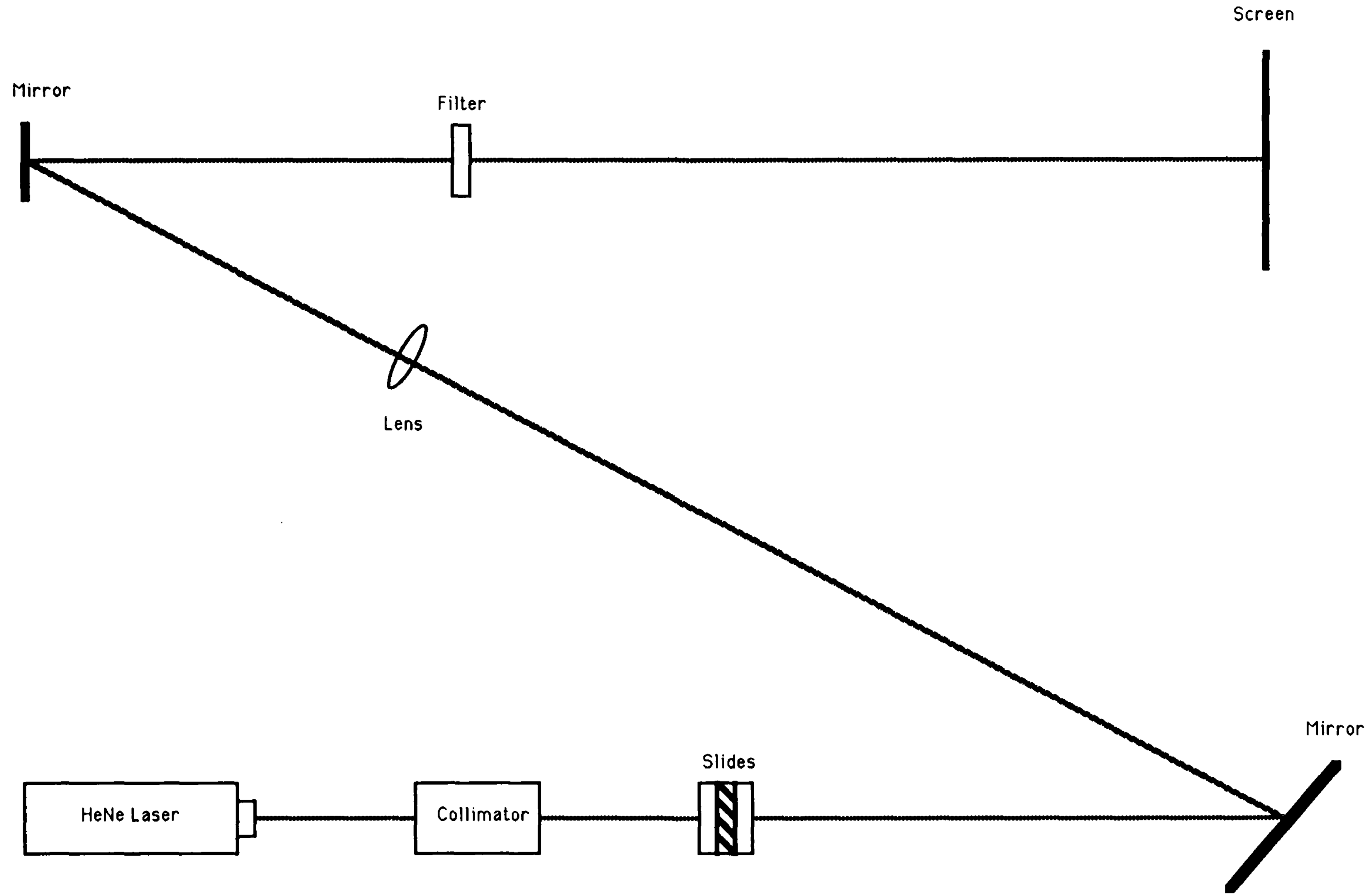


Figure 1. The "Airplane Demo"

SCENARIO FOR ADAPTIVE PROCESSING

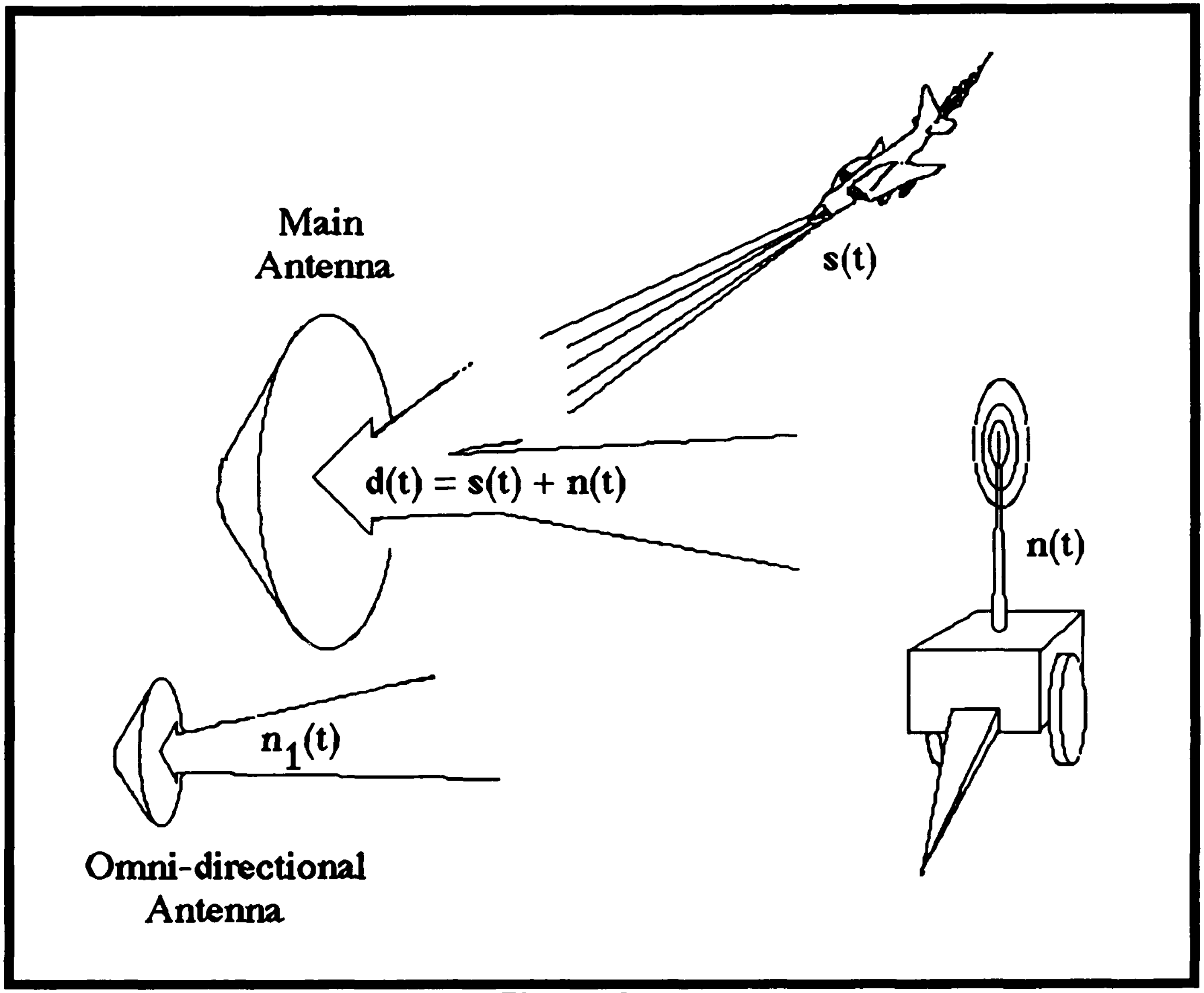


Figure 2.

Figure 3.

THE NOISE CANCELLATION PROBLEM

--Main antenna receives: $d(t) = s(t) + n(t)$

--Auxiliary antenna receives: $n_1(t)$

--Problem: Choose weight vector $\underline{w} = (w_1, w_2, \ldots, w_n)$ so that

$$y(t) = \sum_{i=1}^{n} w_i \, n_1(t - (i-1)\Delta t)$$

is the "best" estimate of $n(t)$

--"Best" estimate: Choose $\underline{w}$ to minimize $\| d(t) - y(t) \|$

by the use of an adaptive version of the steepest descent algorithm, as shown in Figure 4.

All of this process is accomplished by the use of an optical architecture consisting of two subsystems. The first is used to form weight updates, and the second is used to form the estimated noise signal (Figure 5). The whole electro-optic architecture is shown in Figure 6. It is on the LCTV (liquid crystal television) that the weight patterns are displayed, generated by the microprocessor, which adds the old weights to the weight updates from the first system.

The effectiveness of the LCTV was examined through the use of a system as illustrated in Figure 7. The LCTV used was a Radio Shack model. An interesting problem that was found was that the LCTV had a sixty Hz intensity variation, which may have to be compensated for with different electronics. A "signal" cancellation was achieved, as shown in the oscilloscope trace in Figure 8.

From the Optical Processor project, I learned how optical systems may be used to process information.

Figure 4.

THE ALGORITHM

--Minimization problem leads to a linear equation involving a covariance matrix.

--Solve with an adaptive version of the steepest descent algorithm:

$$w_i^{(n+1)} = w_i^{(n)} + a_n \int_{n\tau}^{(n+1)\tau} (d(t) - y^{(n)}(t))\, n_1(t - (i-1)\Delta t)\,dt$$

$$i = 1, \ldots, M$$

Where a_n = scalar stepsize used to control convergence speed,

$y^{(n)}(t)$ = estimated noise using $\underline{w}^{(n)}$ as weight vector,

τ = time between iteration updates.

SYSTEM BLOCK DIAGRAM

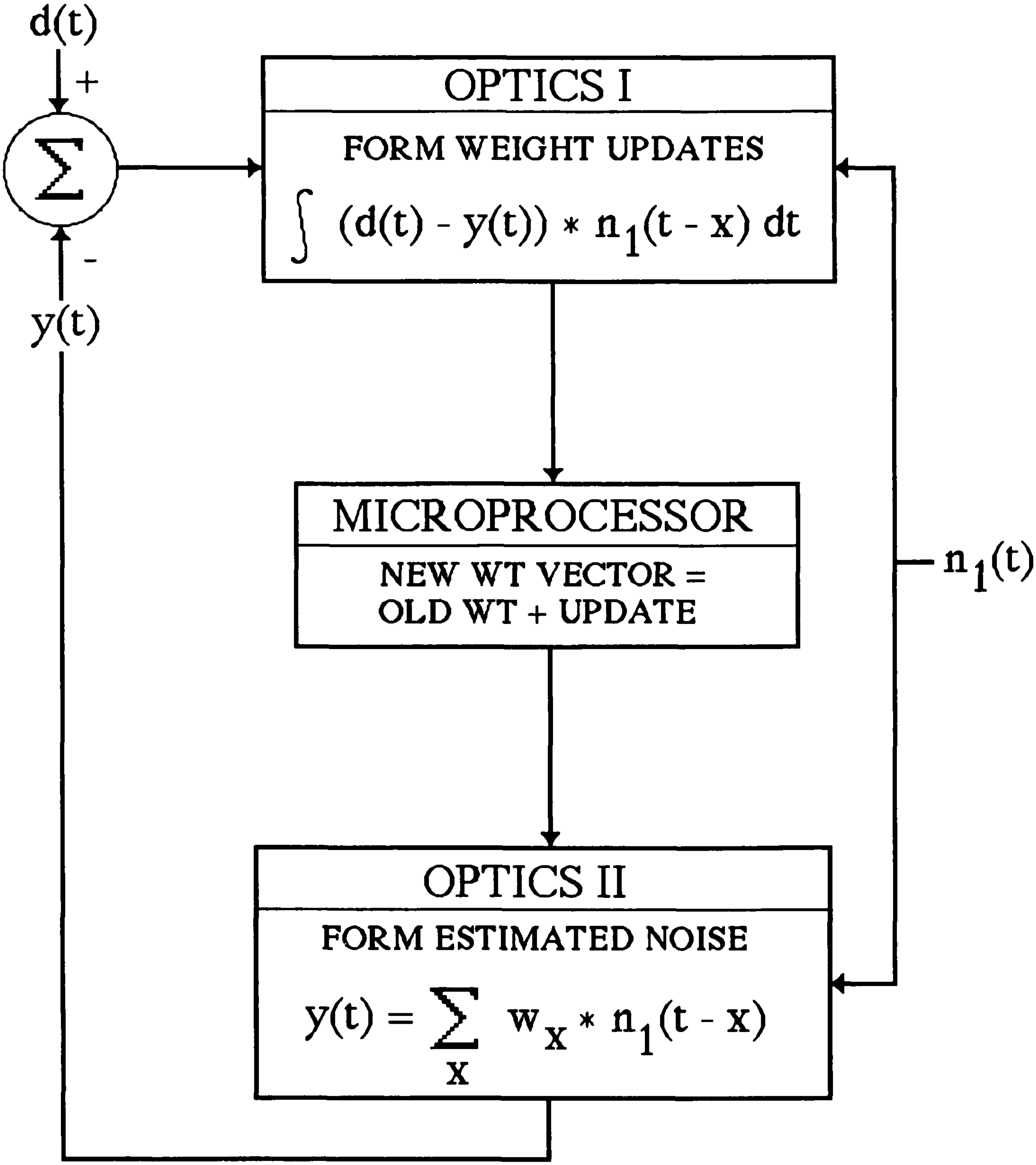


Figure 5.

ELECTRO-OPTIC ARCHITECTURE

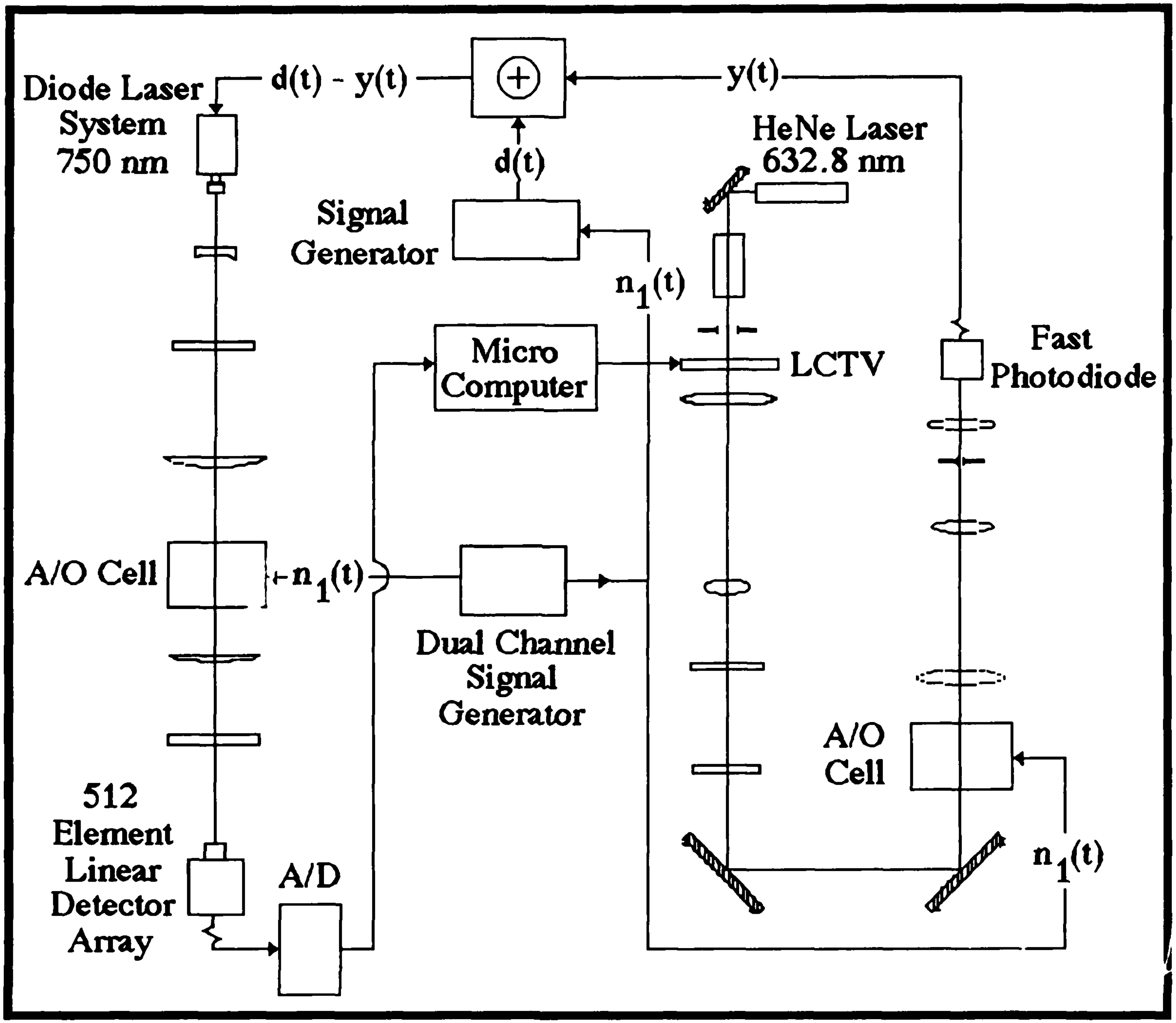


Figure 6.

USE OF LIQUID CRYSTAL TELEVISION AS A 1-D SLM

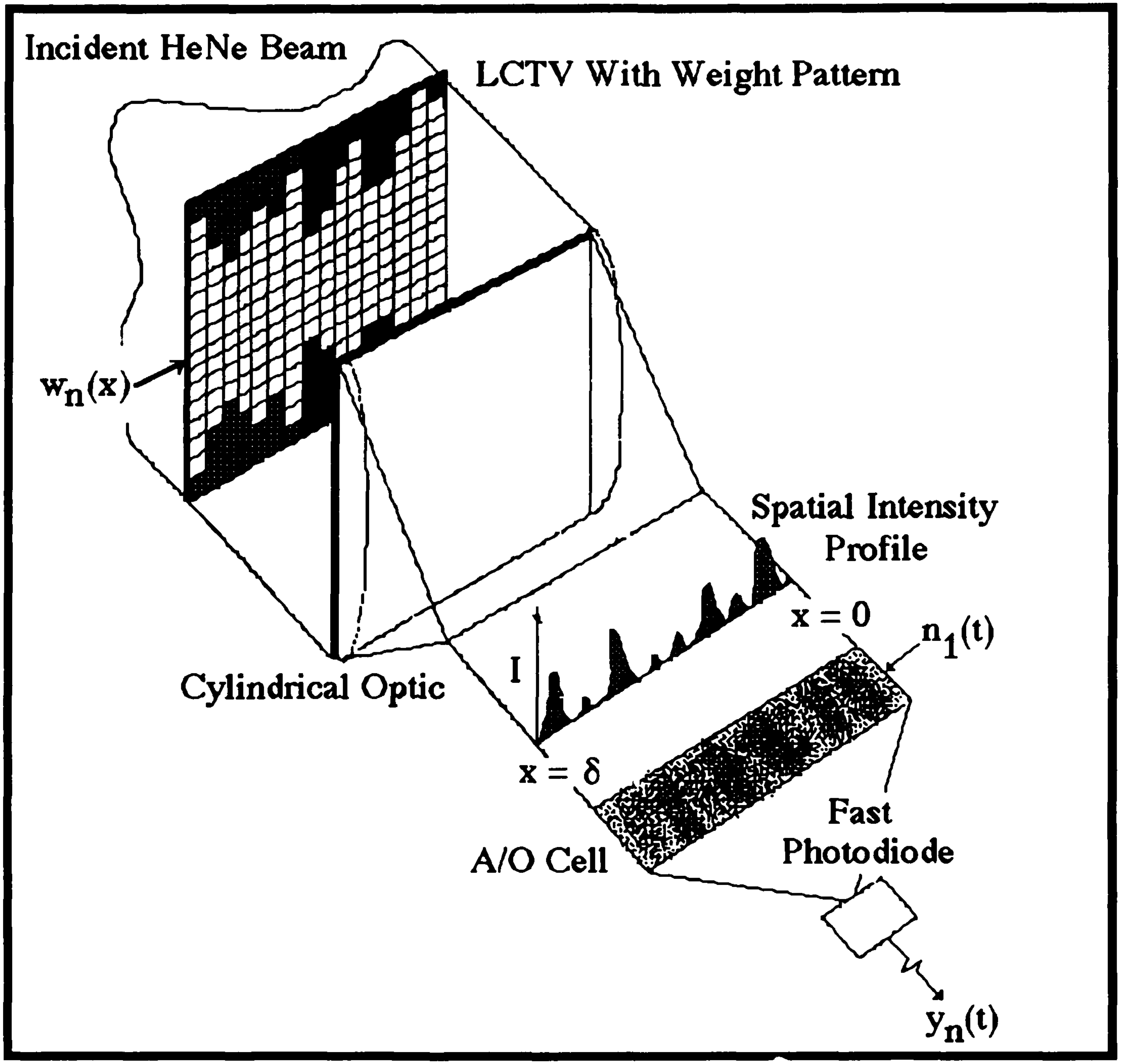
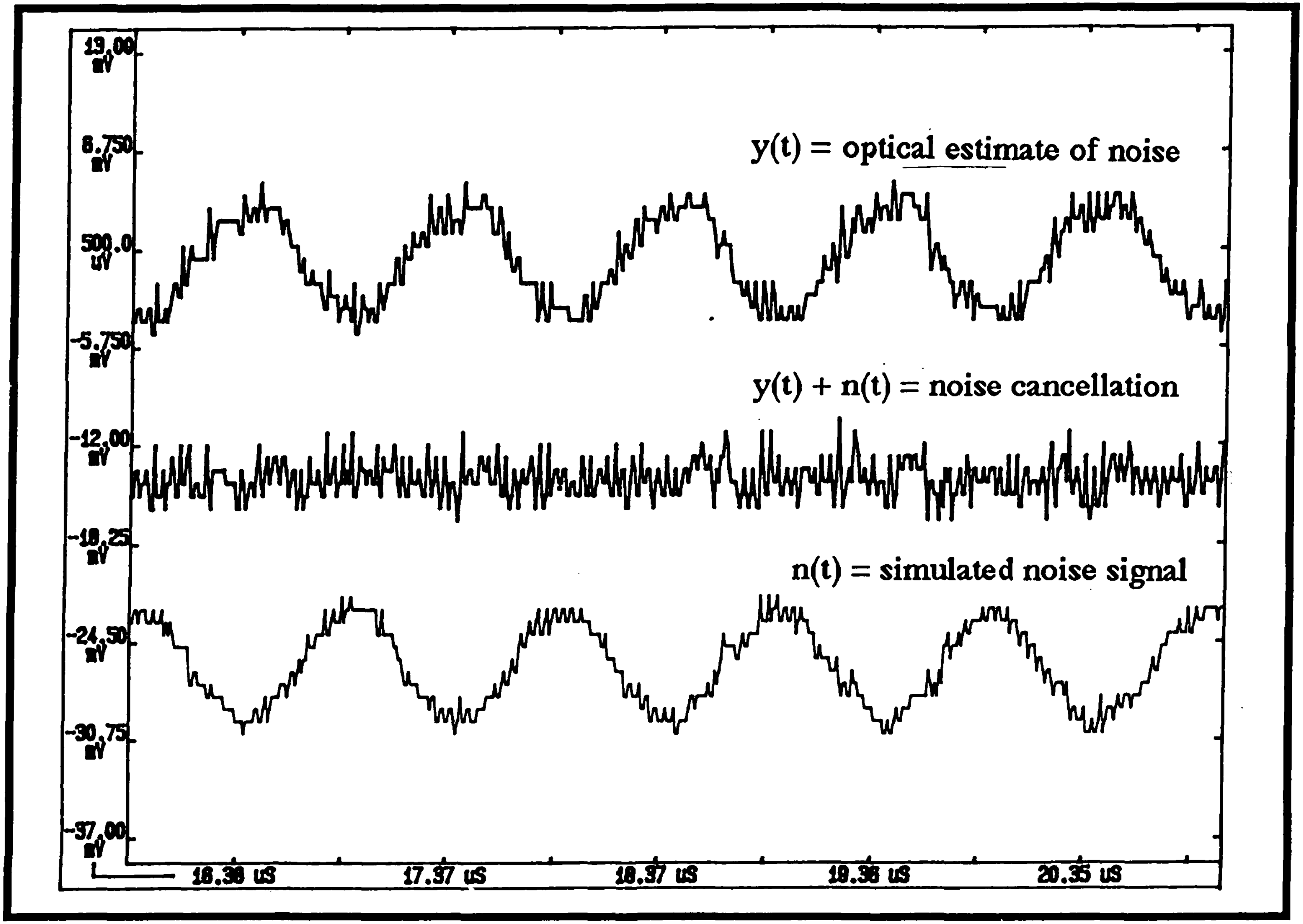


Figure 7.

Figure 8.

NOISE CANCELLATION FOR SINGLE DELAY



III. COMPUTER ENCOUNTERS

One very important aspect of working in a technical environment that I encountered during my apprenticeship was the universal use of computers. The computer experience obtained was broad ranged in terms of exposure to different software.

One system used was the Macintosh II. The different programs contained within this system are: MacPaint, MacDraw II, Pixelpaint, Mathwriter, Mathview Professional, MacWrite II, and Wordperfect. I used these software packages to write this paper. All illustrations were done with MacDraw II, with help from most of the other programs.

Other systems were IBM compatibles consisting of an impressive database and analysis program called Reflex: The Analyst.

The illustrations in this paper were done with Macintosh II programs. For Dr. George Brost, three viewgraphs were generated to be used in his paper, entitled "Photo-Induced Absorption Characteristics of Barium Titanate." The first was a simple diagram of a wavelength passing through a crystal divided into cells. The second was a diagram of a disk, with the equation necessary to calculate the electric field on the axis of a charged disk. The third was a diagram of a waveform through selected cells of the crystal, with the equations necessary to calculate the electric field through a given wavelength.

I learned that computer literacy and ability to use different kinds of software are very important in the technological world, because everything that is done has some sort of computer contribution to its progress.

IV. "Academics"

As was expected, I encountered an academic side to my apprenticeship. I attended several technical presentations on various subjects. One presentation was actually a video presentation issued by the Air Force about Total Quality Management, a concept to help improve relations between management and employees. Two other presentations were given on Gaussian Beams. One was based on a mathematical approach; and the other was presented in geometrical optics to explain the behavior of the beam. Dr. William Kuriger of the University of Oklahoma presented "Basic Concepts of Optical Correlation and Phase-Only Filtering;" describing optical correlation and the utilization of the Fourier Transform of images .

I read two books that I found interesting. The first was Optics, by Hecht and Zajac, in which I learned the history of optics, as well as much about the modern concepts involved. The otherwas An Introduction to the History of Mathematics, by Howard Eves, which I found quite educational.

V. CONCLUSIONS and EVALUATION

During my summer apprenticeship program at the Photonics Laboratory, Analog Optical Processing Branch, I aided in the construction of a model architecture demonstrating the fundamentals of analog optical processing, participated in the final stages of the characterization and utilization of a liquid crystal television in an optical signal processing application, and gained a wealth of computer experience through application of the Macintosh II and IBM systems.

During my apprenticeship program, I've learned about optics, lasers, computers, and their applications to analog optical processing.

I would judge my experience this summer as one of the most worthwhile I have had in preparation for the future. It was fulfilling and educational, and am grateful for having been able to participate in such an excellent program.

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I, Shane M. Stanek, would like to express my sincere thanks to all those whom I worked with and learned from during my stay at the Photonics Laboratory, OPA. A person learns something from every encounter, and so I have from the following people:

Mr. Andrew Pirich

Ms. Denise Blanchard
Dr. George Brost
Mr. Wesley Foor
Mr. David Grucza
Ms. Sandra Halby
Dr. William Kuriger,
U. of Oklahoma
1Lt. Michael Ward, USAF

1989 High School Apprenticeship Program
Cartographic Applications for Tactical and Strategic Systems
Rome Air Development Center
Griffiss Air Force Base, New York
Mentor: Lt. Roderick Holland
Apprentice: Juliet K. Vescio
June 19, 1989-August 15, 1989

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Special thanks also go to Mary Ann Urbanik for her computer expertise and Lt. Matthew L. Kell for always making sure I was busy.

I also want to thank everyone in the Image Products Branch for being so friendly and helpful to me all summer. Thanks to Jeffrey K. Hanson, Delores J. Spado (and her new hairdo that really does look nice), Joseph J. Palermo, Major Lee Peterson, Terence Hallinan (and our delirium over CTAF), James A. McNeely, Stephen J. Hnat (and food from the Plaza), Scott Adams, Mark R. Rosiek, and James A. Sieffert.

Finally, thanks to Lee A. Uvanni of the Image Exploitation Branch for including me in all the retirement and going away parties, and for being my friend.

I. OBJECTIVE

The purpose of my summer apprenticeship was to gain a first hand understanding of scientific methods, to learn how a research laboratory operates, to interact with adult professionals in a work environment, to explore careers, and to become acquainted with the way the United States Government handles its research and development.

II. INTRODUCTION

During the eight weeks of my apprenticeship at Rome Air Development Center, I worked in Cartographic Applications for Tactical and Strategic Systems (CATSS). On my first day I received the proper identification, an orientation on office procedures, and a list of tasks that I would be expected to perform during my stay.

My first priority was to populate the CTAF (CATSS Traceability Analysis Function) Database. This involved inputting various cartographic products into the computer (a Digital VT-240). Throughout the course of the summer I input nine different specification manuals full of cartographic features.

Another task involved taking inventory and cataloging of about 450 digital products. These "digital products" were actually nine-track tapes used to store data. There were more than seven different kinds of tapes, and I devised a system much like the Dewey decimal system used by libraries in order to create an organized filing system.

Other duties included working with the Terrain Perspective Viewer (TPV) to create 2D planar 3D perspective views of flight paths, and evaluating the Combat Honed Airbase Master Planning System (CHAMPS) software, as well as performing regular office services for various people in my branch as need be.

III. DETAILED DESCRIPTION OF TASKS

A. CATSS Traceability Analysis Function

My first priority during my stay at Rome Air Development Center was to populate the CTAF Database. This involved entering into the database hundreds of different cartographic products from nine different specification manuals. CTAF, being a relational database, has the ability to cross mapping products with the Air Force Systems Mapping needs. By entering these product's features, we are able to compare them to a list needed by Air Force Systems (like Mission Support Systems or Decision Support Systems) to produce customer solutions.

In addition to entering cartographic products, I also input the product's feature type (area, point, or line), its dimension (height, width, length, depth, or area), a minimum value for its dimension, and the product's unit of measure (meters or square meters). A typical page of data might look like this:

Product: Topographic Line Map

ID	Feature	Type	Value	Dim	Units
0512	CONVEYOR	LINE	375	LEN	M
0004	MINE	AREA	15625	ARA	SQ
0037	COOLING TOWER	POINT	46	HGT	M
0171	NUCLEAR ACCELERATOR	AREA	40	LEN	M
0016	RAPIDS	LINE	25	WID	M
0840	RESERVOIR	AREA	2500	ARA	SQ

This page of sample data comes from the Topographic Line Map specification manual. In addition to Topographic Line Map, I input data from eight other specification manuals. They were: Digital Terrain Elevation Data (DTED) Level I, Tactical Pilotage Chart, Joint Operations Graphic--Air, Joint Operations Graphic--Ground, City Graphic, Digital Feature Analysis Data (DFAD) Level 1C 2nd edition, Digital Feature Analysis Data (DFAD) Level 3C, and World Vector Shoreline. Most of the specification manuals contained many of the same features, but they often had different minimum value requirements for various dimensions.

As I input each feature for a certain product, I had to ask for Entry Assistance by pushing the PF4 key, in order to go to a glossary to retrieve the proper identification number for each feature. Every feature has its own identification number, as does each type of any given feature. For example, the feature MINE as an AREA might have an identification number of 0004, while the feature MINE as a POINT might have an identification number of 0005. In fact, many features are seen as all three feature types (AREA, LINE, and POINT), while some are seen as only one or two types.

Soon after I began entering features, I ran into a problem. Sometimes a feature that was listed in a specification manual was not listed in the glossary, and therefore, had no identification number. Sometimes a feature was listed in the glossary, but the feature type that was needed was not listed for that feature. In these cases, the feature that I had input was rejected by the computer. When this occurred, I was forced to exit and go to the CTAF Menu in order to "maintain the mini glossary". There I was able to enter the feature I wanted, the proper feature type, a definition of the feature, and it was assigned an identification number. I could then re-enter the Product's Features section and input the product.

A complete listing of features that had to be input for each product is as follows:

Tactical Pilotage Chart

Conveyor (no line feature)
Amusement Park Attraction (no area feature)
Drive-in Theatre (no area feature)
Building (no area feature)

DFAD Level 1C 2nd Edition

Stadium/ Ampitheatre (no listing; use Stadium)
Mobile Home, Mobile Home Park (no listing; use Mobile Home Park)
Dock (no listing; use Drydock)
Rock Strata, Rock Formation (no listing; use Rock Formation)

City Graphic

Firing Range (no listing area)
Complex Outline (no listing)
Dam (no area feature)
Lock (no area feature)
Nursery (no area feature)
Aqueduct (no point feature)
Current Arrow\ Flow Arrow (no point feature)
Conveyor (no point feature)
Embankment (no area or line feature)
Missile Site (no area or point feature)

Topographic Line Map

Tent Dwellings (no listing; area and point)
Scrub/Brush (no area feature)
Bog (no area feature)
Lock (no area feature)
Hummock (no area feature)
Geophysical Prospecting Grid (no listing)

DFAD Level 3C

Hedgerow (no area feature)
Orchard/Plantation (no line feature)
Lake/Pond (no line feature)
Dam (no line feature)
Filtration/Aeration Beds (no area feature)

Although having to stop and enter each of these features was a hassle, I had other problems with CTAF that were much more severe. One day the system went wacky, and this appeared on my screen:

```
vdb_stmt is:  fetch current
from stream:  start_stream current using R in feature with R.
                                               Feature_ID=5

%RDB_E_STREAM_EOF, attempt to fetch past end record stream

%TRACE_E_TRACEBACK, symbolic stack dump follows

module name          routine          line
validate        v_fix_form_fields     2603
validate        v_entry_assist        2328
utility         u_data_entry_keys     1580
SHELL$MATCH_WIL   SHEL$MATCH_WILD

FMS               f_getal             2580
FMS               f_getform           1823
A_Prod_Feat       a_prod_feat         3121

v_fix_form_fields:  fetch failed.
status code:  20480426
```

This came as a surprise, and I was forced to turn off my computer and start again, losing several pages of data that I had not yet saved. Another problem with CTAF, and the reason why I had not yet saved such a large amount of data, was the fact that recovery time was so slow. Saving just one page of data took between seven and ten minutes, so it was more convenient to just type in large quantities of data and then leave the machine to save while I went to lunch or when I left for the day.

Perhaps the most frustrating problem I had while working with CTAF was that the Intelligence and Cartographic Facilities (ICF), where the computers I needed for CTAF were located, was a secret facility. Unfortunately, I do not have secret clearance. That meant that every time I wanted to go into the ICF to work on CTAF, I had to find an escort who would walk me into the facilities and remain with me for the entire duration of my stay, and then walk me out. It was not always easy to find some one who had time to do this, so I lost a lot of time that I could have been working on CTAF. Also, I felt uncomfortable always having to ask some one to take me back because I felt that he or she must surely have more important things to do.

B. <u>Digital Products Inventory</u>

The digital products inventory was probably the most difficult task I had to perform, because when I arrived the tapes were in a terrible disarray, with in no particular order or location for any of them. It took me several days to determine which tapes that were listed in the old inventory were actually still existing in the laboratory somewhere. After several more days of gathering stray tapes from office desks, odd corners of the lab, and unopened boxes, I tried to create some semblance of order.

As I said before, there were several different kinds of tapes: Digital Terrain Elevation Data (DTED) Levels I and II, Digital Feature Analysis (DFAD) Levels I and II, Landsat Data, World Vector Shoreline, World Data Bank II, as well as several other varieties that contained only a few tapes. First, I separated each of these into their proper groups. Then I took only DTED Level I tapes with a north latitude and an east longitude and began arranging them in order of descending latitude. For tapes with the same latitude, I put them in order of descending longitude. There were 231 of these DTED tapes with north latitude and east longitude, each of which was given a white label with a red stripe along the bottom. The label identified the tape as a DTED Level I, Lat. N/Long. E, and gave the exact latitude and longitude that the tape covered. Each tape was also given a four digit number to keep it in order, with each shelf beginning a new set of numbers. For example, DTED Level I Lat. N/Long. E covers five shelves, so call numbers range from 0001 to 4027.

The same thing was done for the other tapes as well. DTED Level I tapes with a north latitude and a west longitude were given white labels with a blue stripe, and they were assigned a four digit call number. And so on, for DTED Level II, DFAD Levels I and II, World Vector Shoreline, and World Data Bank II. (See label reference sheet.) Landsat tapes, however, were a different story. Most Landsat tapes cover an area which is divided into four sections, each section being divided into three more sections, so that for any area of Landsat data there are twelve different tapes. For Landsat data, I referred to each area by a letter, the section by a number, and the mini-section by another number. (See Landsat data chart.)

Organizing these tapes was probably my favorite task because I was given free reign to devise my own filing system. The worst part about this task, however, was the inadequate filing space allotted for the many tapes, as they require special filing cabinets. This made it very difficult to keep all of the like tapes together, and we have already run into problems as more tapes are arriving.

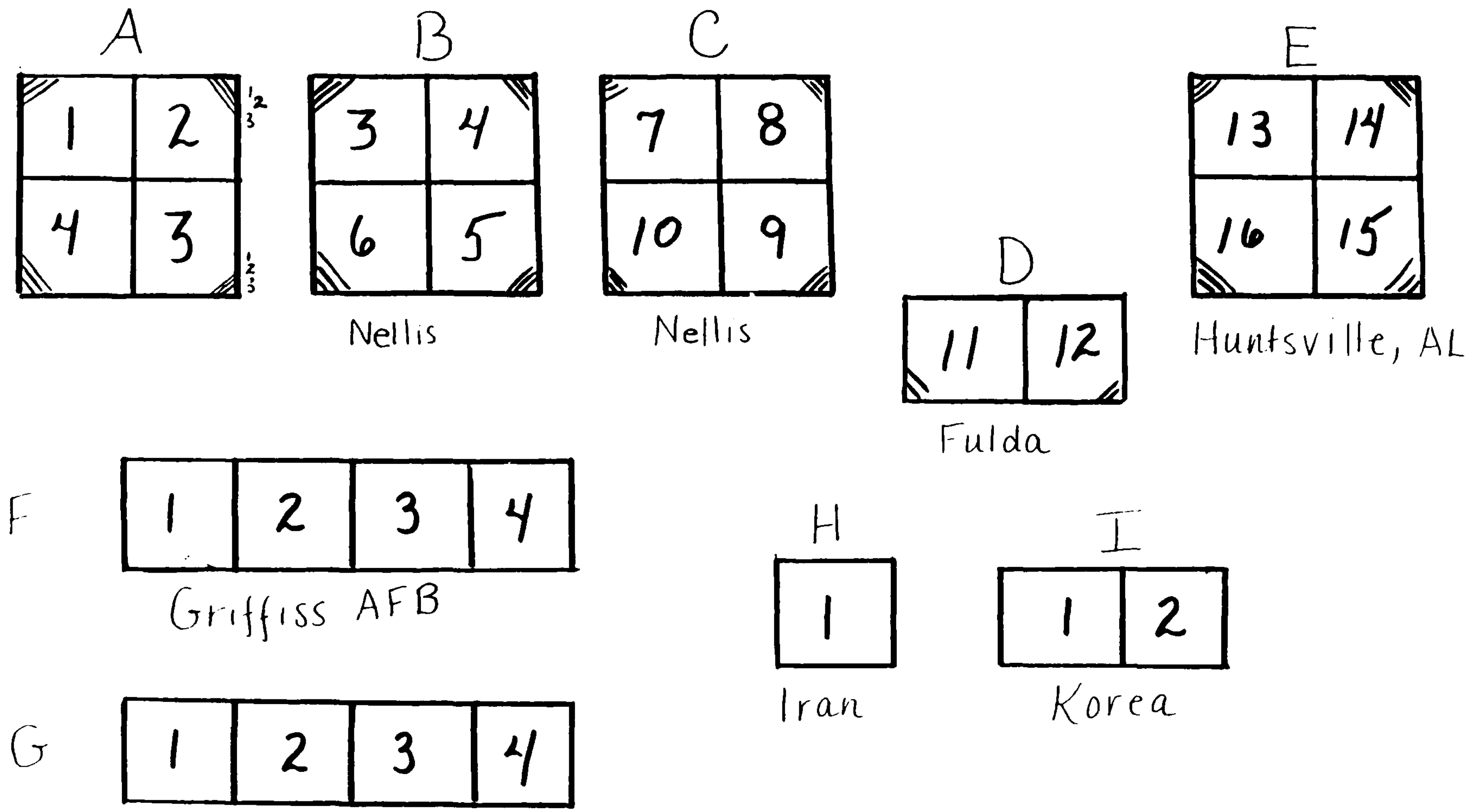
C. Terrain Perspective Viewer

The Terrain Perspective Viewer (TPV) is a prototype workstation which allows the user to create 2D planar and 3D perspective views of terrain which pilots might encounter during tactical air missions. Other than learning how to use the TPV, I did very little work with it. However, my experience with the

Digital Products Reference Sheet

DTED Level I Lat N/ Long E	0001 - 4027
DTED Level I Lat N/ Long W	4030 - 5039
DFAD Level I Lat N/ Long W	6001 - 7003
DFAD Level I Lat N/ Long E	7004 - 7009
DFAD Level II	7010 - 8029
DTED Level II	9001 - 9007
Landsat Data	—
World Vector Sh[illegible]	10001 - 10017

Landsat Data Chart



TPV was unique and valuable in that I learned for the first time how to use a mouse, which makes the work a lot easier.

D. Combat Honed Airbase Master Planning System (CHAMPS)

The CHAMPS software was given to me in the very beginning of my stay, but I never really had time to do anything with it, since there was never an appropriate PC available for my use. I was intrigued by it, though, and I found it very disappointing that I did not have the opportunity to work with it. CHAMPS is a decision support system for siting air base facilities and utilities to maximize their operability and survivability in a combat environment.

IIII. RESULTS

Although I will not be able to see the results of my work, it will hopefully help in the larger research of the Cartographic Applications group. Lt. Kell has informed me that the time I spent entering data into CTAF was invaluable to the building of the larger relational database, not to mention the fact that it allowed him to spend his time on other things. My mentor, Lt. Holland seemed impressed with my work on the digital products inventory, and we are both hopeful that the system I devised will remain in use after I leave and will keep tapes the digital products where they belong, so that they can be taken care of, not lost.

V. CONCLUSIONS

This summer experience was definitely not one which I will forget. Although I did not learn about the field I plan to enter, I did gain valuable experience in working with computers, which I found to be very interesting, as it was a field which I had not considered. I also got a taste of a real research laboratory environment, as well as a real work environment. Finally, I met dozens of really interesting, educated people who took a lot of their time to talk to me about their work and their schooling.

INFRARED CAMERA USER'S MANUAL

Prepared by

Katie Ward

for

Daniel S. Benincasa

RADC / OCSA

Griffiss AFB, N.Y.

13441-5700

IR SURVEILLANCE LAB
(IRSL)

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Introduction

This manual was published for use in the Infrared Surveillance Lab(IRSL), RADC, Griffiss AFB, NY. Its primary reason for being published was so that anyone that was not familiar with the system could efficiently utilize it by themselves. This manual will also be sent to different contractors as part of the explanation of what this system is capable of and what its future capabilities will be. With the help of my co-workers this manual will be upgraded as neccessary and will grow with the future system.

Section 2
BACKGROUND

The Infrared Surveillance Lab (IRSL) was built to exploit the potential benefits of using an IR sensor to support the ADI mission of detecting, tracking, classifying and identifying low observable threats such as cruise missles and cruise missle carrying bombers. A PtSi 64 x 128 element IR camera has been incorporated into the system to test its performance and to determine the roles in which an IR system could support the ADI mission.

The present capabilities of the Infrared Surveillance Lab (IRSL) include the ability to manually acquire and track airborne targets of opportunity within a 250 NMI radius of the Griffiss AFB area. Utilized is the J-SS NORAD radar, which displays target azimuth, slant range, altitude, and identification and a remotely controlled pan and tilt pedestal system which houses both the visible and PtSi IR camera systems. The IRSL can record 8 bit video information from both the visible and IR cameras through a VHS recording system. The ability to record and display 12 bit digital data from the 64 x 128 PtSi camera using a VME based computer onto a 9 track tape recorder. In addition to recording capability the VME based computer supports the OS-9 operating system which will allow real-time image processing of the 12 bit digital data.

By FY 90 the capabilities of the IRSL will have expanded to include the following. Automatic target aquisition and tracking with the PtSi 64 x 128 IR camera, including the implementation of clutter suppression algorithms for enhanced performance. The automatic hand-over of track information from the J-SS NORAD radar to cue the IR tracking system. The system's hardware will also be updated to include a 80 MFLOP array processor for the VME based computer as well as a 12-bit display capability.

The long-term goal of the facility is to be a resource for testing a variety of IR sensor systems. This will allow for the detection, testing and evaluation of multicolor, multispectral, temporal and spatial processing techniques to determine their potential role in supporting the overall ADI mission. Data fusion is a major thrust in supporting ADI surveillance.

The capability of the IRSL to perform data fusion between multi-color IR, viIR, visible and radar information will provide a testing ground for the evaluation of both Government and contractor developed algorithms for enhanced detection, tracking, classification and identification. In addition to directly supporting ADI surveillance, the IRSL will be available to support a variety of IR/EO data collection experiments and system performance analyses.

Section 3
INITIAL STARTUP IN IRSL

3.1 Procedure

The IRSL is located in Room F-150 of Building #106:

3.1.1 Power Switches/Buttons

The following switches and buttons must be turned on to operate the Visible/IR Camera and Pedestal. They are located in the center section of the Control Console. (See Figure 9)

1) the red push button marked POWER near the TILT indicators (light underneath it will be illuminated when on)

2) the two square yellow push buttons below the Visible/IR display monitors (they should be illuminated when on)

3) the visible/IR display monitor power switches marked Power/Vol

The UHF/VHF scanner is located above the IR Camera Processor. (See Figure 8)

4) Power/Vol Switch is located on the front of the scanner

3.2 Post Startup of IRSL

3.2.1 Obtaining Liquid Nitrogen

In order to effectively operate the IRSL, the IR camera FPA must be cooled to 77 K. This can be accomplished by cooling the FPA with Liquid Nitrogen (LN_2).

Where to Go

The Nitrogen may be obtained from either Building # 106 or Building # 3. If you are going to obtain the Nitrogen from Building #3, it is best to take someone with you so they can hold onto the Nitrogen while you are driving, if this is not feasible then place the Nitrogen on the floor in the back seat. If you do not have a back seat have someone hold onto the bottle in the front seat.

Enter Bldg #3 from the East Side Entrance near the LN_2 1000 tank. Once inside, on your left is a red safety cabinet on the wall which contains the needed safety glasses and a pair of gloves for your use. In order to obtain the LN_2, you have to enter through Don Calabrese's lab which is on your right (E-90). The tank is a 1601 LN tank, located just inside the door on your left. Try not to disturb him if possible, but if you need more LN_2, he is the one to ask.

The LN_2, can also be obtained from Bldg #106 by the same process mentioned above.

What to Do

Start filling the carrying tank by placing the nozzle from the nitrogen in its neck and slowly turn the valve counterclockwise located on top of the tank.

3.3 Filling the Camera Dewar with the Nitrogen

3.3.1 Safety Precautions

When NOT to Go on the Roof

If any of the antennas are running, or if you think that the C-Band is running, DO NOT go on the roof. If you aren't sure if the C-Band is running or not, check with OCTS to see when they are planning to run it.

When NOT to Use the Camera

Do not use the camera when it is raining out, the rain may damage the electronics inside the camera head.

3.3.2 How to Get to the Roof

After filling the Nitrogen bottle proceed to the roof of Bldg. #106, If the door to the roof is closed for some reason then use the elevator located at the end of Corridor C and push the top button until you reach the next floor, then proceed to the camera location.

3.3.3 How to Fill Camera

1) Make sure that you are wearing the safety glasses located on the top shelf inside the grey cabinet

2) Use the funnel that is provided on the shelf to pour in the Nitrogen

3) Unlatch the front and top access doors

4) Place the funnel in dewar and quickly pour in the LN_2 in so that it does not evaporate before getting into camera.

5) When liquid starts to spew out, wait for a few seconds and then pour in a little more. Do this two or three more times until it is full.

6) Retighten the clamps on the top access door and check with someone in the lab (if there are two people) to see that everything is correct. (Use the intercom system located in the cabinet, do not push the button to talk, just to get in touch with the person in the Lab.)

7) If focusing is needed turn the outside portion of the lens using small increments.

8) Return the funnel and eye protection back in to the grey cabinet.

3.4 Returning to the Lab

3.4.1 What to Turn on Before Use of Camera (See Figure 8)

Turn the function switch to DIRECT then push square red power button.

3.4.2 Waiting Period

It is important to wait about fifteen minutes for the camera to cool down and be ready for use.

3.5 Adjustment Switches/Buttons

The following buttons and switches are locatec on the IR Camera Processor (See Figure 8)

1) DEFECT ELIMINATOR - Non-operational

2) BACKGROUND AVERAGE - Turn function switch to BACK AVE, hit white push button marked BACK AVE the button will be illuminated for about a half of a second. When operated in Background Average Mode, this will sample 16 frames, take the average incident radiation on the focal plane and store it in the memory. (ALWAYS return the function switch back to DIRECT before changing BACK AVERAGE again)

3) FREEZE FRAME - This will freeze an 8 bit video frame displayed on the monitor

4) INVERT IMAGE - This button will invert the grey scale of the intensity from white/hot and black/cold to white/cold and black/hot.

5) AUTOMATIC BLACKLEVEL - Non-operational

6) PARITY LIGHT - Should be illuminated (deals with fiberoptic error)

7) NOISE ERROR - Should NOT be illuminated (deals with fiberoptic error)

8) DEFECT - Non-operational

9) FUNCTION SWITCH - Composed of four different modes, DIRECT, COMP, BACK AVE, and STORED.

A) DIRECT - Is what you are actually looking at.

B) COMP - Compensates or subtracts what is not wanted on the screen

C) BACK AVE - Explained in 2) BACKGROUND AVERAGE

D) STORED - Displays what was in memory (average for 16 frames)

10) MANUAL LEVEL - Used for fine gain adjustment

11) GAIN SWITCH - located between manual and automatic level. It is the coarse setting for DC (Direct Current) offset

12) AUTOLEVEL- Non-operational

The following are located on the Pedestal Control Box (See Figure 9)

13) PAN METER - Will give a relative azimuth deflection angle from a given zero

14) TILT METER - Will give a relative elevation deflection angle from a given zero

15) LARGE KNOB - Located near the two yellow push buttons, is the speed adjustment for the pedestal (fast-slow)

16) ZOOM IN OR OUT - In order to zoom in or out on an object, use the buttons marked zoom located nearest to the joystick. Used only for visible camera.

17) FOCUS - Used for visible camera only

18) IRIS - Non-operational- automatically adjusts for the visible camera

19) JOYSTICK - This will reposition pedestal in a new azimuth or elevation angle.

The intercom is located on the shelf in front of the Pedestal Controller, make sure it is turned off inside the Lab when you are done using it. If for some reason the intercom is not working, check the following:

1) The batteries

2) The wires, check for continuity

The UHF/VHF scanner is located above the IR Camera Processor. (See Figure 8)

Scan - If you would like to hear all the different channels.

Manual - If you want to hear only certain channels at a time.

3.6 Different Suggestions on Using the System

3.6.1 DIfferent Ways of Tracking Targets

1) Manual searching (joystick control)

2) Using the NORAD JSS data available on the Electrohome Color monitor (located on the left). (Used for cueing)

3) Knowing where and when the flight patterns will occur

4) Being able to interpret the data coming from the air traffic control UHF/VHF scanner.

4.0 USE OF DATA AQUISITION SYSTEM

4.1 Startup of System

The following steps must be taken before the system can be utilized:

1) Unlocking the Keyboard

   In order to utilize the keyboard on the Data Aquistion System you have to unlock it with the keys that are hanging on a hook in back of the computer in the blue section. After obtaining these place key in the keyboard lock located on the left side of keyboard, and turn counter clockwise to symbol that shows an open lock.

2) Power Switches Turned on

   Located on the front of the Heurikon there is a power on button, push to turn on the power. Located on the back of the computer is a red power button, this also needs to be switched on in order to utilize the computer system.

NOTE: Always use SHIFT and <- (Backspace) to delete a letter or word

3) Push the RESET button located on the front panel of the computer and wait for the red LED labeled HALT to go on and then off before releasing.

4) At the prompt > type br, then push enter.

   >br <enter>

5) At the prompt debug, type g, then push enter.

   debug>g <enter>

6) At the prompt Boot Device: (H/F), type H for Hard Disk , then push enter.

   Boot Device: (H/F) H <enter>

7) When prompted to enter date and time, type as you are asked, then push enter.

```
yy/m/dd hh:mm:ss      [am/pm]    <enter>
For example:
89/07/31 09:05:00       a           <enter>
```

8) At the prompt User Name, type USR1, then push enter.

```
User Name ?  USR1 <enter>
```

9) At the prompt password, type PW1 (This will not appear on screen but will access the computer.

```
Password?  PW1  <enter>
```

10) At the $ prompt type ir

```
$ ir  <enter>
```

NOTE: (After typing this in any directory, it will bring up the Main Menu)

NOTE: The CLOCK light on the Heurikon should be illuminated while the system is in use.

4.2 Use of System for Efficient Collection of Data

1 What menus there are and how to use them

Real Time Data Aquisition System

Main Menu

0 Stop (Enter LOGOUT to exit)
1 Capture data and save to hard disk
2 Capture data and save to tape
3 Capture data to hard disk to tape
4 Move data from hard disk to tape
5 Move data from hard disk to memory
6 Move data from memory to hard disk
7 Print memory contents
8 Extract frames from hard disk
9 Print frame data files
10 Tape drive utilities
11 Image display functions
12 Reserved (Non - Operational)

UTILIZATION OF DATA AQUISITION MAIN MENU

1 CAPTURE DATA AND SAVE TO HARD DISK

Enter file size in bytes (<4194304): For 8 seconds captured type 4000000

Enter number of files on hard disk: Each file= 8 seconds, if more than that add accordingly

File names on hard disk: IR000- ...

wait...

Data aquisition finished!

2 CAPTURE DATA AND SAVE TO TAPE

Enter number of transfers (4MB/Transfers):

Enter number and hit <enter>:

Data aquisition finished!

3 CAPTURE DATA TO HARD DISK TO TAPE

Enter number of files on disk

Enter number of tranfers to tape

File names on hard disk

Data aquisition finished!

Data tranfer 1 completed

4 MOVE DATA FROM HARD DISK TO TAPE

Enter number and hit <enter>

Enter file name

Enter number and hit <enter>

5 MOVE DATA FROM HARD DISK TO MEMORY

Enter base address in hex:

Enter file size in bytes (<4194304):

Enter file name:

6 MOVE DATA FROM MEMORY TO HARD DISK

Enter base address in hex

Enter file size in bytes (<4194304):

Enter file name

7 PRINT MEMORY CONTENTS

Enter base address in hex

Enter adddress offset in decimal

Print in decimal(0) or hex(1): Enter (0) or (1)

8 EXTRACT FRAMES FROM HARD DISK

Enter file size in bytes (<4194304):

Enter input filename

9 PRINT FRAME DATA FILES

Enter input file name:

10 TAPE DRIVE UTILITIES

Hit <enter> and Tape Menu will appear (explained in next pages)

11 IMAGE DISPLAY FUNCTIONS

Hit <enter> and Display Menu will appear (explained in next pages)

12 RESERVED (NON OPERATIONAL)

TAPE MENU

0 RETURN TO MAIN MENU

1 REWIND TAPE

2 SPACE FORWARD

3 SPACE BACKWARD

4 READ RECORD FROM TAPE

5 WRITE RECORD TO TAPE

6 WRITE FILE MARK

7 SEARCH FOR FILE MARK FORWARD

8 SEARCH FOR FILE MARK BACKWARD

9 MOUNT TAPE

10 DISMOUNT TAPE

ENTER A NUMBER AND HIT <ENTER>

UTILIZATION OF DATA AQUISITION TAPE MENU

NOTE: ALWAYS MOUNT TAPE FIRST (REFER TO NUMBER 9)

1	Rewinds to beginning of the tape
	NOTE: Make sure it stops spinning
2	Space Forward
	Enter Number of Blocks (<256)
3	Space Backward
4	Enter Block Size In Bytes (<=12000)
	Enter Number of Blocks (<=256)
5	Same as # 4
6	No Entry Required
7	No Entry Required
8	No Entry Required
9	DO THIS FIRST
10	No Entry Required

———DISPLAY MENU———

0 RETURN TO MAIN MENU
1 DISPLAY ANALOG VIDEO IMAGE (CH. 1)
2 DISPLAY ANALOG I.R. IMAGE (CH. 2)
3 DISPLAY ANALOG VIDEO IMAGE (CH. 3)
4 DISPLAY ANALOG VIDEO IMAGE (CH. 4)
5 SELECT OUTPUT LOOK - UP TABLE
6 DISPLAY I.R. IMAGE
7 STILL PICTURE
8 SAVE VIDEO FRAME TO HARD DISK
9 RESTORE VIDEO FRAME FROM HARD DISK
10 SELECT OUTPUT LOOK - UP TABLE
11 CLEAR VIDEO SCREEN 1
12 CLEAR VIDEO SCREEN 2

ENTER A NUMBER AND HIT <ENTER>

UTILIZATION OF DATA AQUISITION DISPLAY MENU

0 RETURN TO MAIN MENU - self explanatory

1 DISPLAY ANALOG VIDEO IMAGE (CH. 1) - Displays 8 bit analog video output from visible camera

2 DISPLAY ANALOG I.R. IMAGE (CH. 2) - Displays 8 bit analog video output from IR Processor/Camera

3 DISPLAY ANALOG VIDEO IMAGE (CH. 3) - For future use in a three or four camera surveillance system

4 DISPLAY ANALOG VIDEO IMAGE (CH. 4) - For future use in a three or four camera surveillance system

5 SELECT OUTPUT LOOK-UP TABLE - Selects display color bar
CHOICES (0-7)
0 = GREY SCALE IMAGE
(1-7) Different color bars for false color

6 DISPLAY I.R. IMAGE - 12 bit IR data
Bit Shift prompt >(0-4)
Present system ha 8 bit display capability. In order to display data recorded in 12 bits we may select which bits to be displayed.

7 STILL PICTURE - Does the same as Freeze Frame

8 SAVE VIDEO FRAME TO HARD DISK - ?

9 RESTORE VIDEO FRAME FROM HARD DISK - ?

10 SELECT OUTPUT LOOK-UP TABLE - ?

11 CLEAR VIDEO SCREEN 1 - self explanatory

12 CLEAR VIDEO SCREEN 2 - self explanatory

ENTER A NUMBER AND HIT <ENTER>

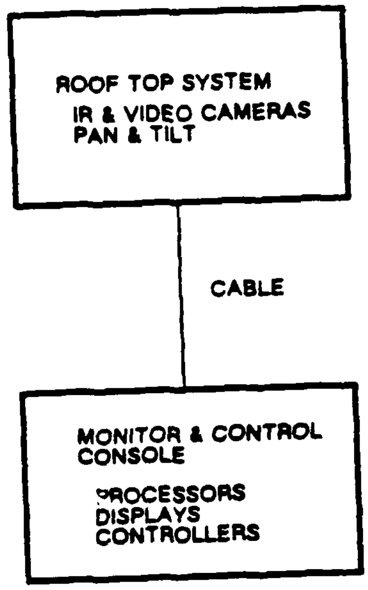


Figure 1 RADC OCSA INFRARED CAMERA SYSTEM FACILITY GENERAL OUTLINE

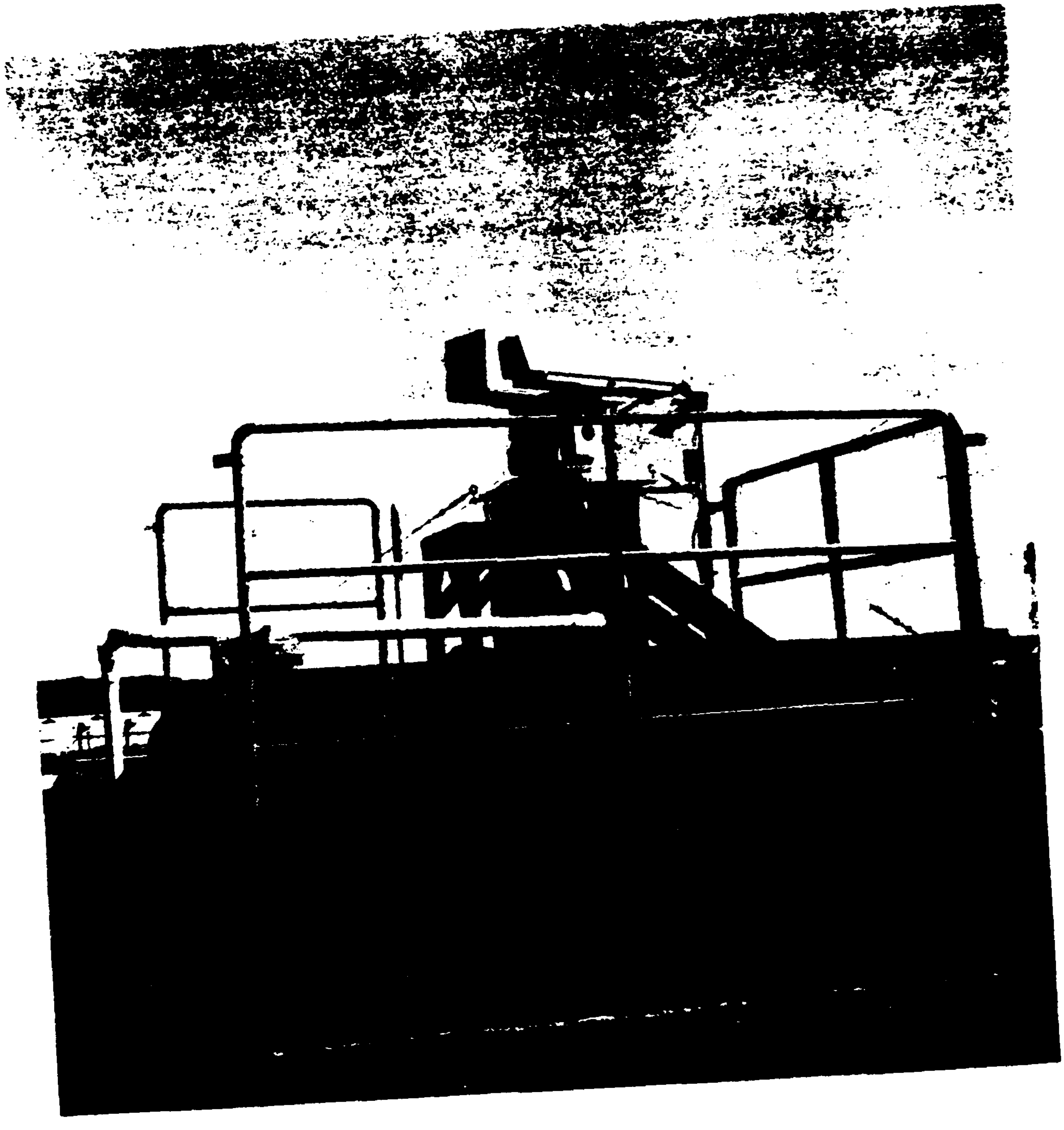


Figure 2 ROOFTOP SYSTEM

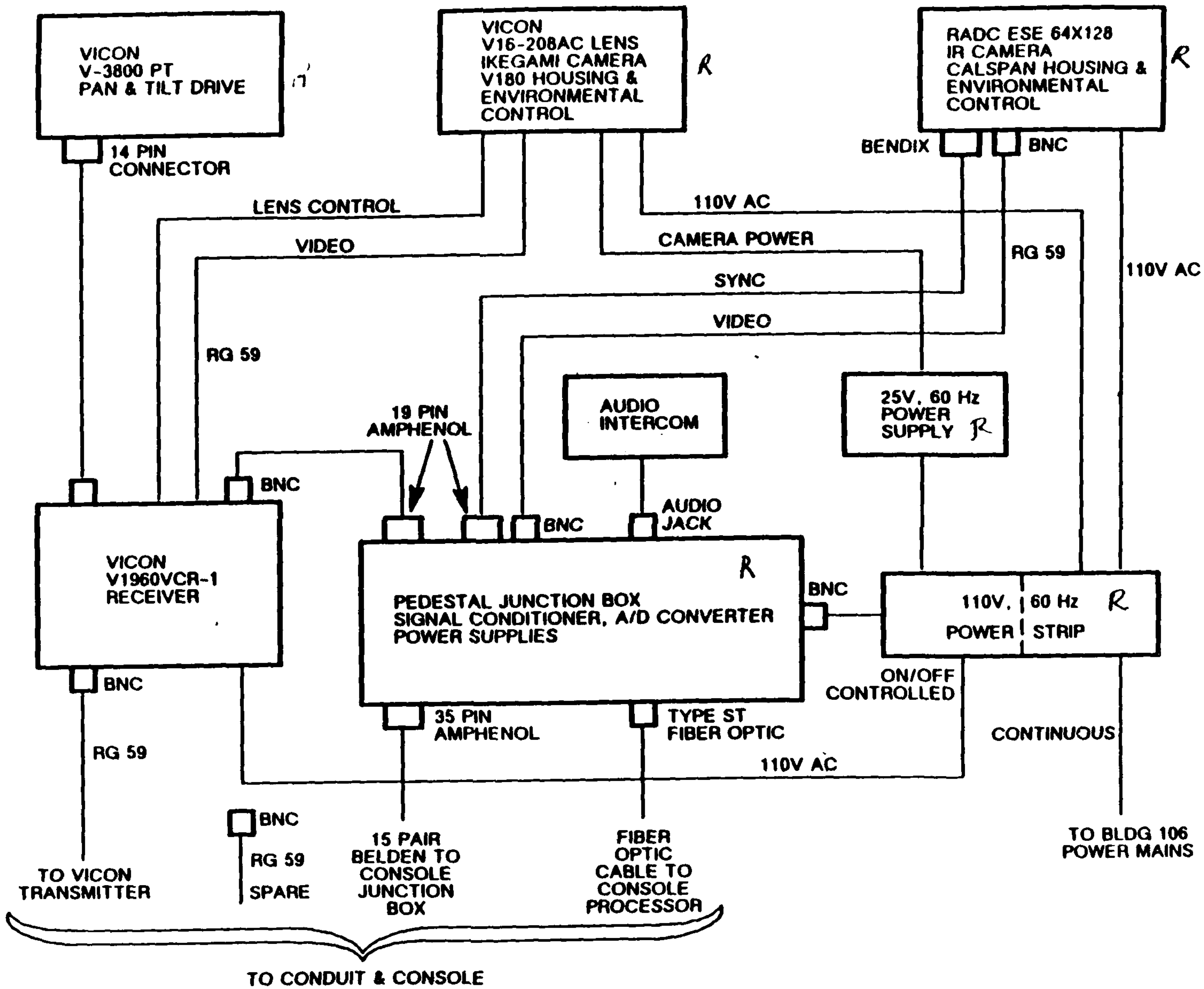


Figure 3 FUNCTIONAL BLOCK DIAGRAM, ROOF TOP SYSTEM

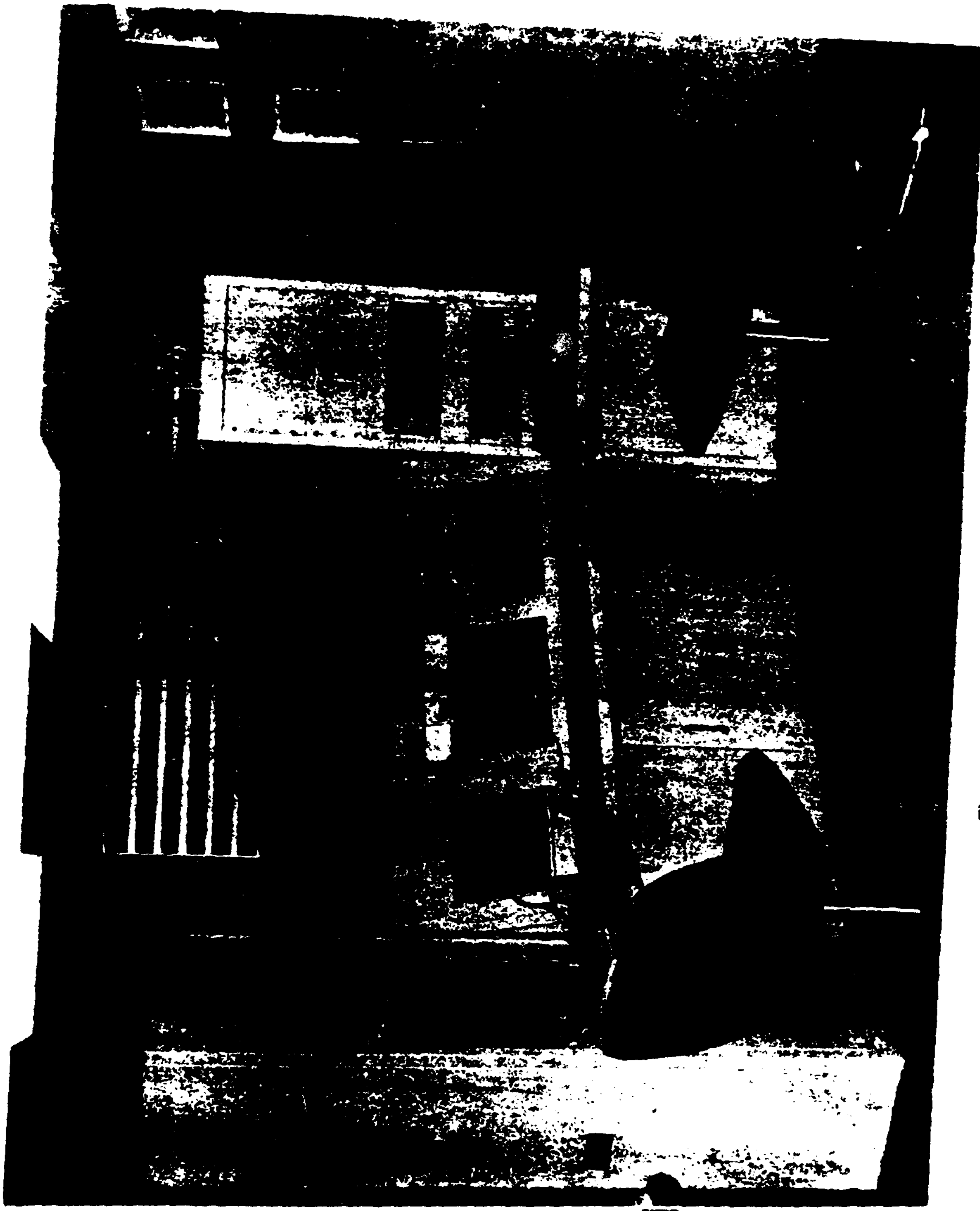


Figure 4 LABORATORY CONSOLE

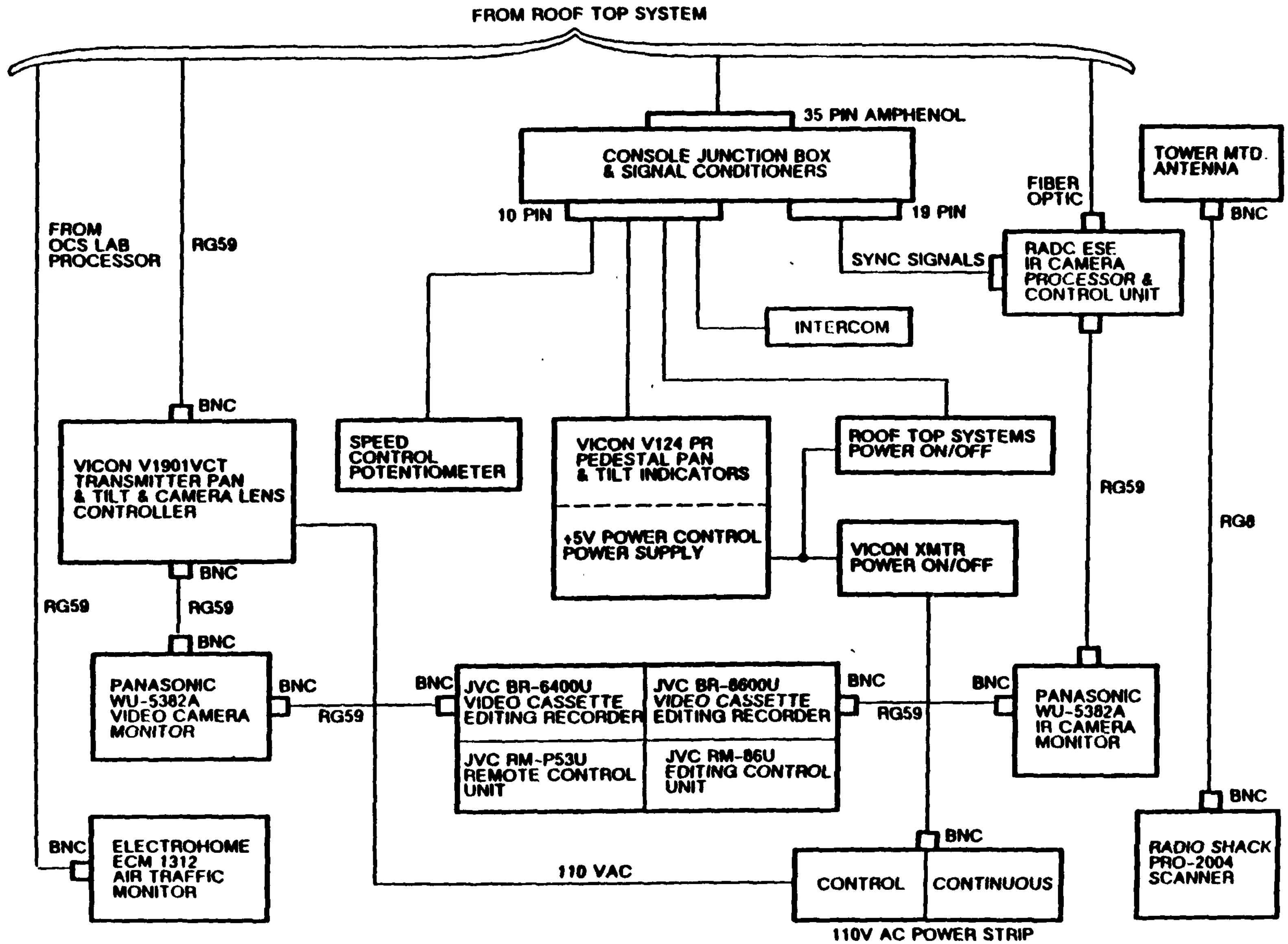


Figure 5 FUNCTIONAL BLOCK DIAGRAM, MONITOR AND CONTROL CONSOLE EQUIPMENT

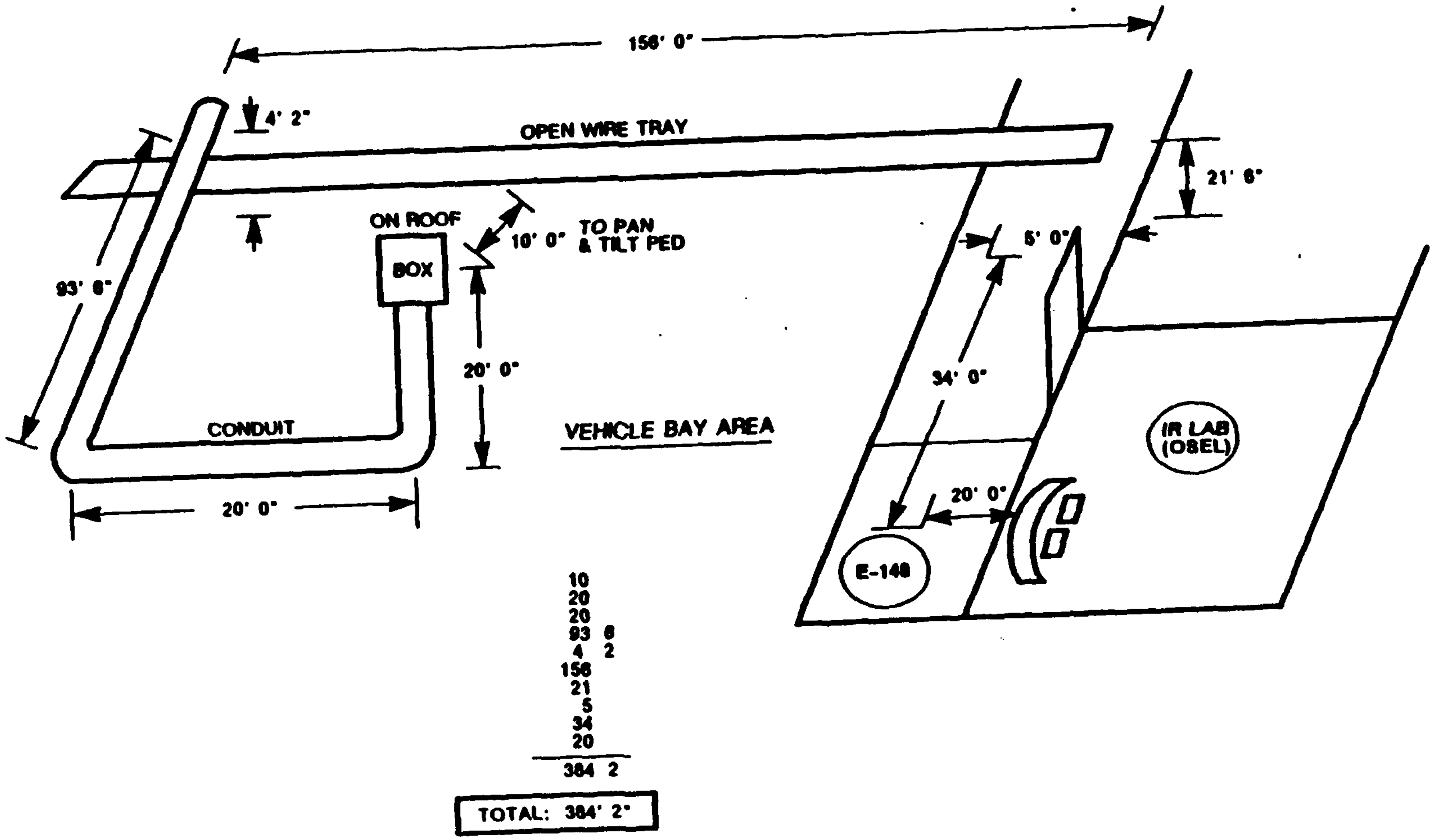


Figure 6 CABLE RUN FROM ROOF TO OCSA LABORATORY

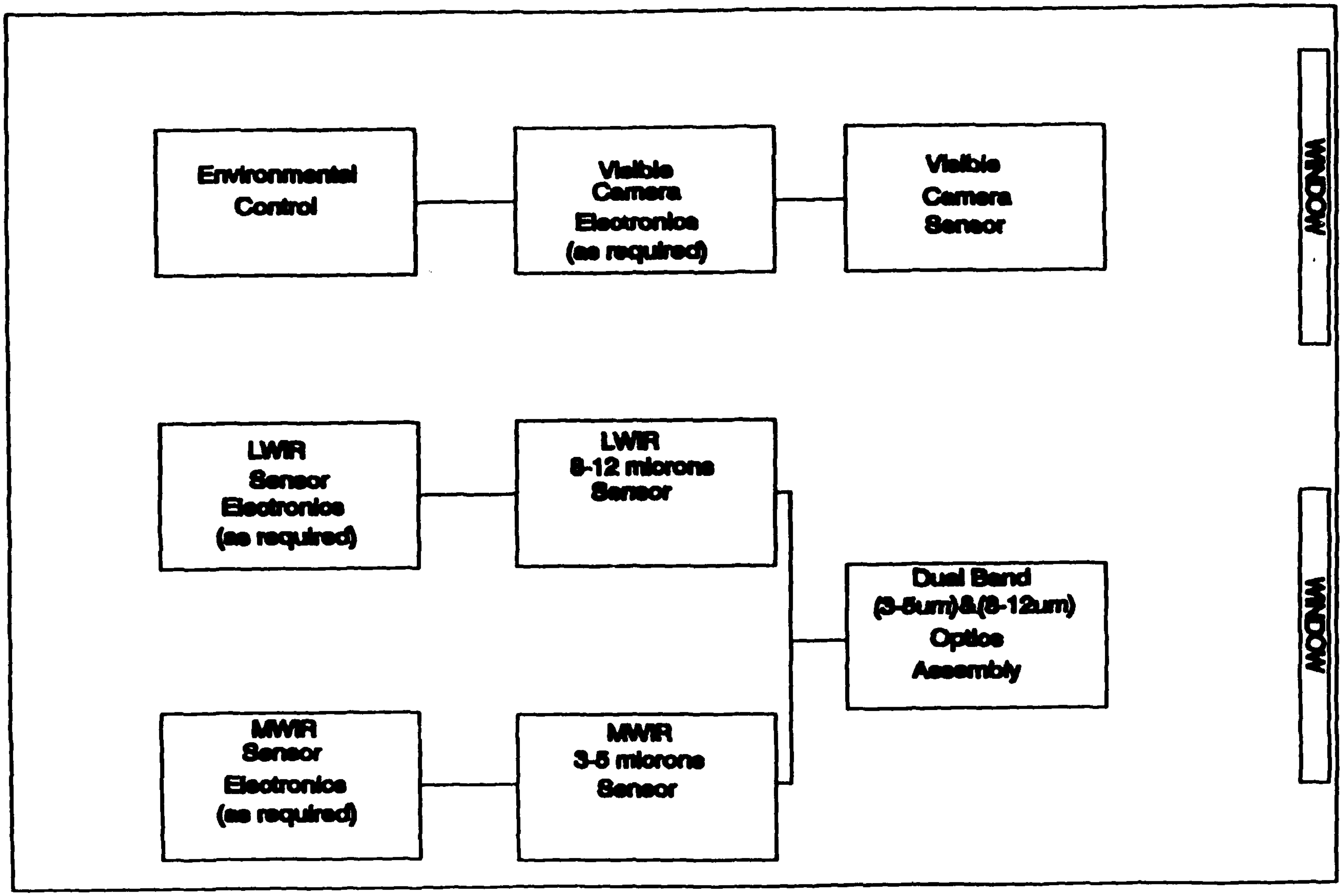
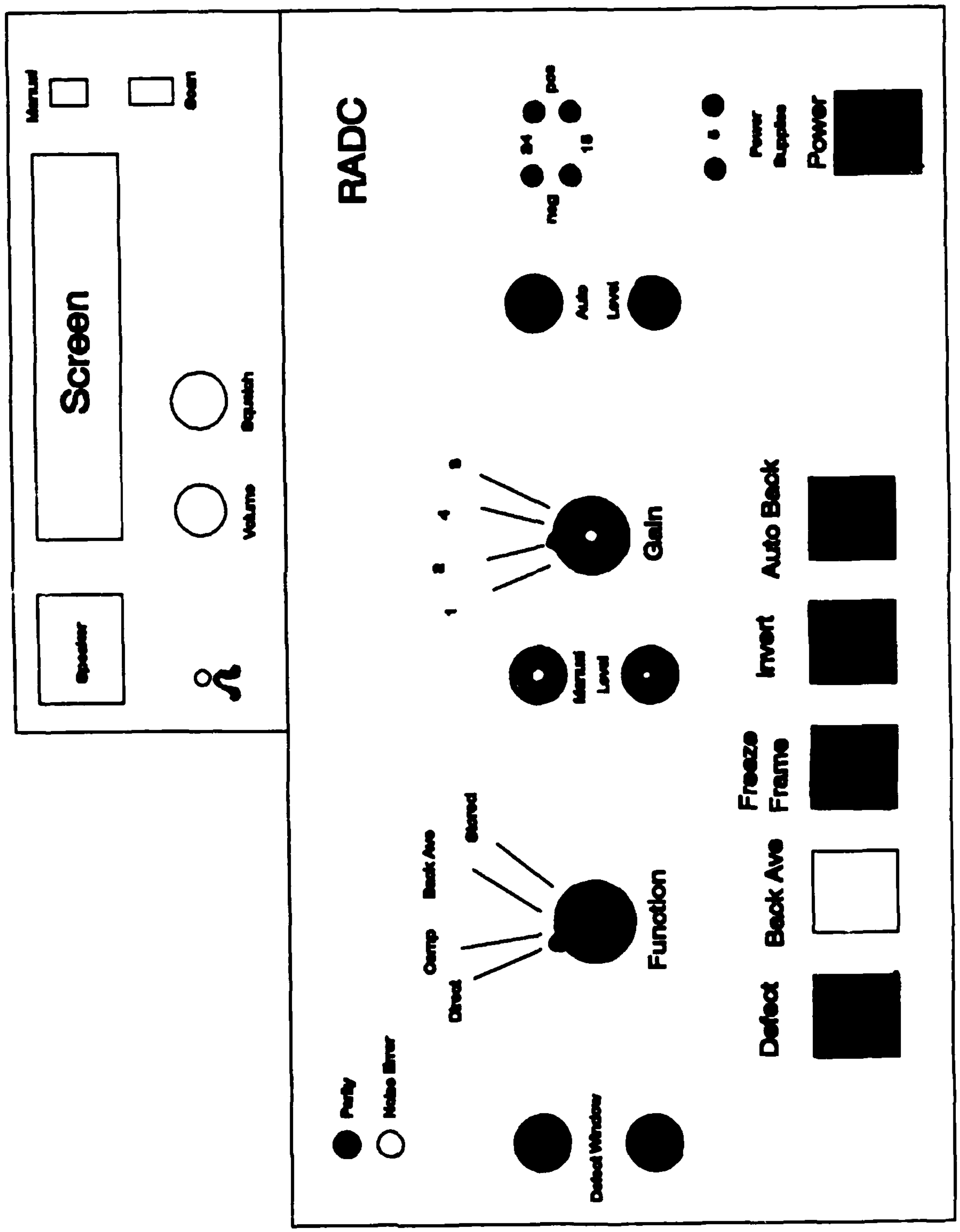
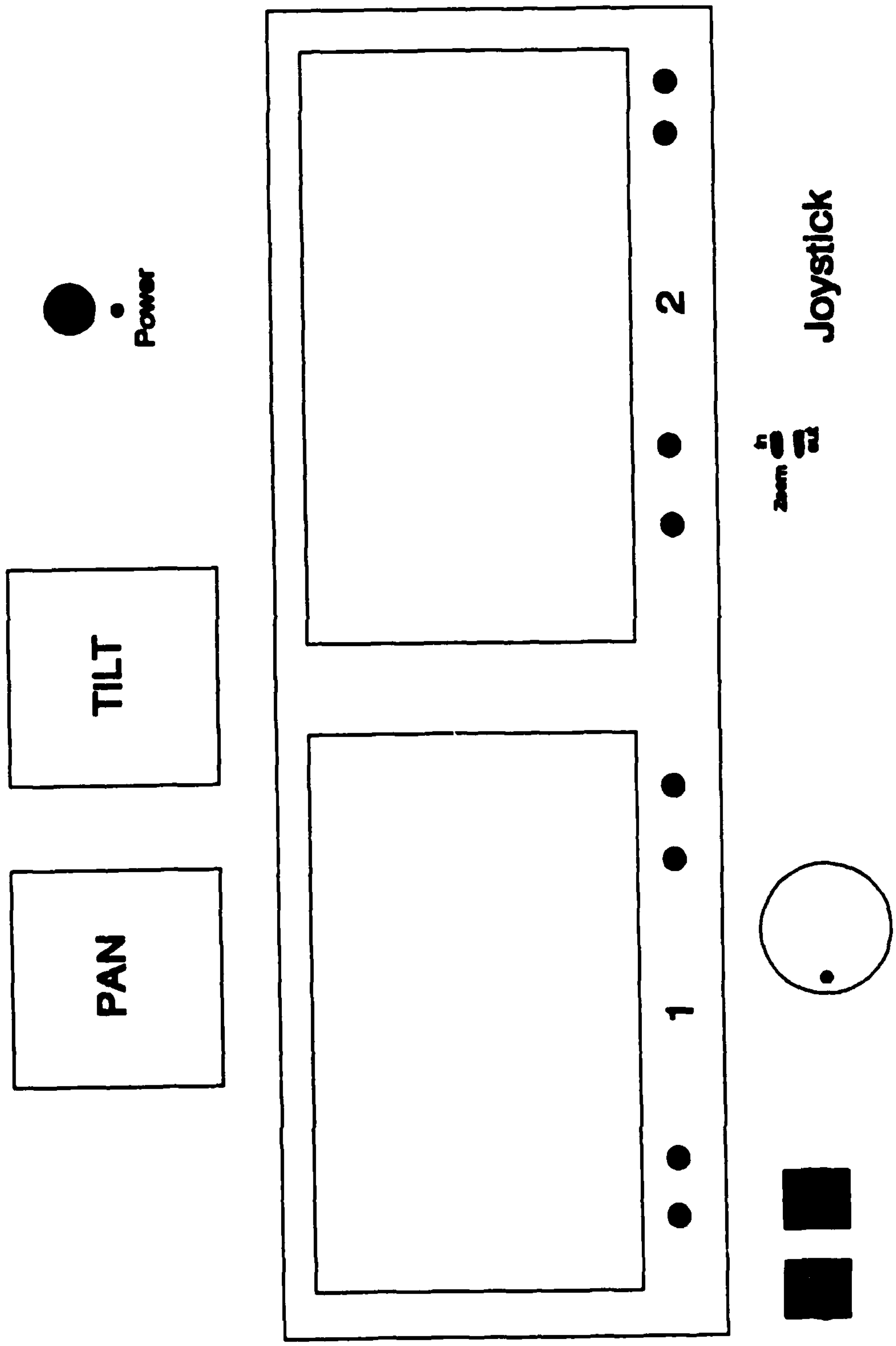


Figure . D.B. Optical System Block Diagram


Manual
Scan
Screen
Speaker
Volume
Squelch
RADC
neg
24
pos
15
5
Power Supplies
Power
Auto Level
Manual Level
1
2
4
8
Gain
Auto Back
Invert
Freeze Frame
Back Ave
Defect
Direct
Comp
Back Ave
Stored
Function
Parity
Noise Error
Defect Window


Power
TILT
PAN
2
1
Joystick

IRSL PRESENT CAPABILITIES

- Manual Aquisition & Tracking of Airborne Targets
- 8-Bit Analog Recording Capability (VHS)
- 12-Bit Digital Recording Capability for IR Sensor System (VME Computer & 9 Track Tape Drive)
- J-SS NORAD Radar Display of Targets within 250 NMI of Griffis AFB (Azimuth, Slant Range, Altitude, Indentification)
- Monitering of Aircraft Radio Calls (VHF/UHF Radio)
- Capability for Real Time Processing (VME Computer & OS-9 Operating System)

IRSL UPGRADED CAPABILITIES (1 JAN 90)

- Automatic Aquisition & Tracking of Airborne Targets
- Automatic Hand-over from J-SS Radar to IR Aquisition & Tracking System
- Implementation of Clutter Suppression Techniques (Real Time)
- Upgraded Pedestal System
- Array Processor (60 MFLOPS) Added to VME Computer

IRCCD FOCAL PLANE ARRAY (FPA)

Detector Material	PtSi
Detector Size	40 x 80 $(mm)^2$
Active Area	52 x 27 $(mm)^2$
Fill Factor	44 %
Quantum Efficiently	2 %
FPA # of Elements	64 x 128
FPA Size	268 x 272 $(mil)^2$
FPA Nonconformity	0.5 %
Dynamic Range	80 dB

Operating Conditions

Wave Band	1- 5.5 mm
Temp	77 K
Cooling System	LN_2 (Dewar)

Optical System

f / nos	1.8
Focal Length	100 mm
Band Pass	3.4 - 4.2 microns

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3) Avco Research Laboratory
Amos User Manual

A STUDY OF OPTIC TURBULENCE

By Barbara Westfall

RADC/OCSP
Mr. Tim Busch
June-August 1989

Universal Energy Systems

Working at RADC/OCSP has been an interesting and a learning experience. When I first began working at OCSP, I had no prior backround in electronics and I was basically unfamiliar with the electronic field. So, I would like to thank the people of OCSP for making me feel like I was a part of the branch. Your help and hospitality was very much appreciated.

I would especially like to thank the other students that I worked with at OCSP. Tom LaBatt, Jim O'Connel, Don Stanchfield and Fredrick Proni were all willing to work with me on my project, show me how to use the equipment, or answer my questions. I'm glad I had the opportunity to get to know them. Thanks for making my work experience over the summer fun and unforgettable.

Most of all I would personally like to thank my mentor Mr. Tim Busch who has been helpful from the very beginning. He was very willing to explain things more than once and he would always answer my questions -no matter how simple they may have been.

My name is Barbara Westfall and I have been working on a project at RADC/OCSP at the Griffiss Air Force Base in Rome, New York. Most of my time was spent working at PORTL (Percision Optical Research Testing Lab) in Verona, New York.

My summer project is entitled "A Study of Optical Turbulence". To begin, I'll explain what turbulence is. Turbulence is fluctuating air possibly caused by air mixing or temperature variations. For example, on a hot day when you're driving on the highway the road looks wet and you can see what looks like heat waves moving above the road. This is turbulence, the motion distorts what the road really looks like. The same thing occurs in the atmosphere when viewing the sky. For this reason, it is important to measure turbulence so that we may be able to correct much of the distortion.

OBJECTIVE: My objective was to construct a photodiode system to be used to study turbulence and install it.

APPROACH: Before I began constructing my photodiodes, I learned about how they work. A photodiode is a semiconducting device used for detecting and measuring energy. Using Figure 1, I will describe how a photodiode works. The PIN photodiode is made up of three regions, the

P region, the depletion region and the N region. The P region is in the front of the diode. The N region is in the back. The high resistivity material of the I-layer or depletion region is also called the intrensic region. The P region is very thin and allows even the shortest of wavelengths to enter. For the best results, you want to get the wavelengths to end up in the depletion region so that the photons separate into their electron-hole pairs.

The photodiode works in this manner: When a photon of light is absorbed, an electron-hole pair is formed -meaning that when the pairs are separated, the electrons go to the N region and the holes are left in the P region and thus photocurrent results. Ideally, each photon should cause a contribution of one electron to the stream of photocurrent, but this does not hold true. Even though there are numerous numbers of photons entering the photodiode, they don't all reach the depletion mode. Because of this, not all of them will separate into electron-hole pairs. The percentage of electrons given off is called the quantum efficiency.

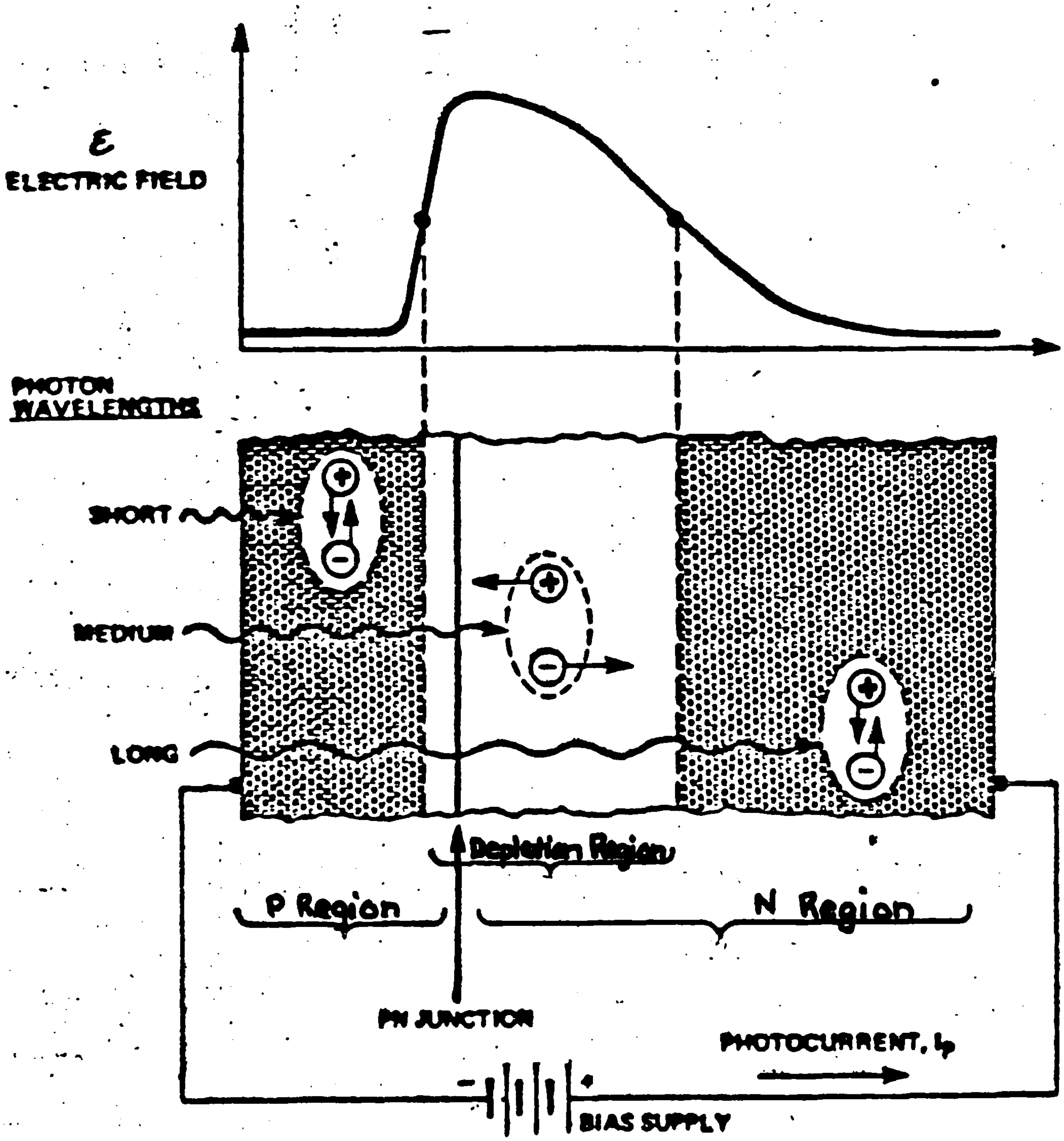
DESIGN: When constructing the apparatus, I used a copper board approximately 1 inch in width and 2 1/2 inches in length. I used 2 boards each containing a photodiode, an op amp and a 120 K resistor. (Fig. 2) I soldered wires to the various pins on the op amp. The op amp is necessary to make the system work. The resistor is used for determining the scaling factor of the results. It makes the results larger and therefore easier to measure. I am using two photodiodes because as they are moved farther apart from each other and farther apart from the mirror, the turbulence is expected to become greater.

I completed and tested both photodiode set ups. I attached a rubber clamp to the end of each board. The clamps are used to allow the diode boards to be easily moved along the rod. I installed the rod as close to the primary mirror as possible. The diodes will have to be hooked up to some type of regulated current flow and the output will be connected to an oscilloscope. (Fig. 3) When making the turbulence measurements, you will have to take different measurements at different times of the day and account for interferences such as temperature changes.

RESULTS: The photodiodes are installed and are ready to begin measuring. Unfortunately, due to the fact that my stay at RADC is over, I will not be able to start the turbulence measurements. Instead, I will explain the results that would be expected. After making numerous measurements at different times, days and heights from the mirror you should calculate your data and begin plotting your results in graph form. The graph would be the intensity of the light vs. the voltage. Hopefully the graph looks like something similar to Fig. 4. As the graph shows, the intensity of light should be directly proportional to the voltage. In an ideal or perfect conditions, the line would be diagonally straight. In real conditions, the line would not be straight do to interferences of nature i.e. temperature change. Eventually the depletion region of the photodiode will become staurated and the graph will get to a certain value and level off.

The optic turbulence study was the main project that I have been working on over the summer. Working on this project has helped me become more familiar with the electronics field. I've learned that your job may become very frustrating, but it also has its rewards. It was difficult at times, but I know that I am better for taking on the challenge and learning through the experience.

FIG. 1



P-N Photodiode Junction; Diagram of Internal Field Effect on Detection.

FIG. 2 Photodiode Board

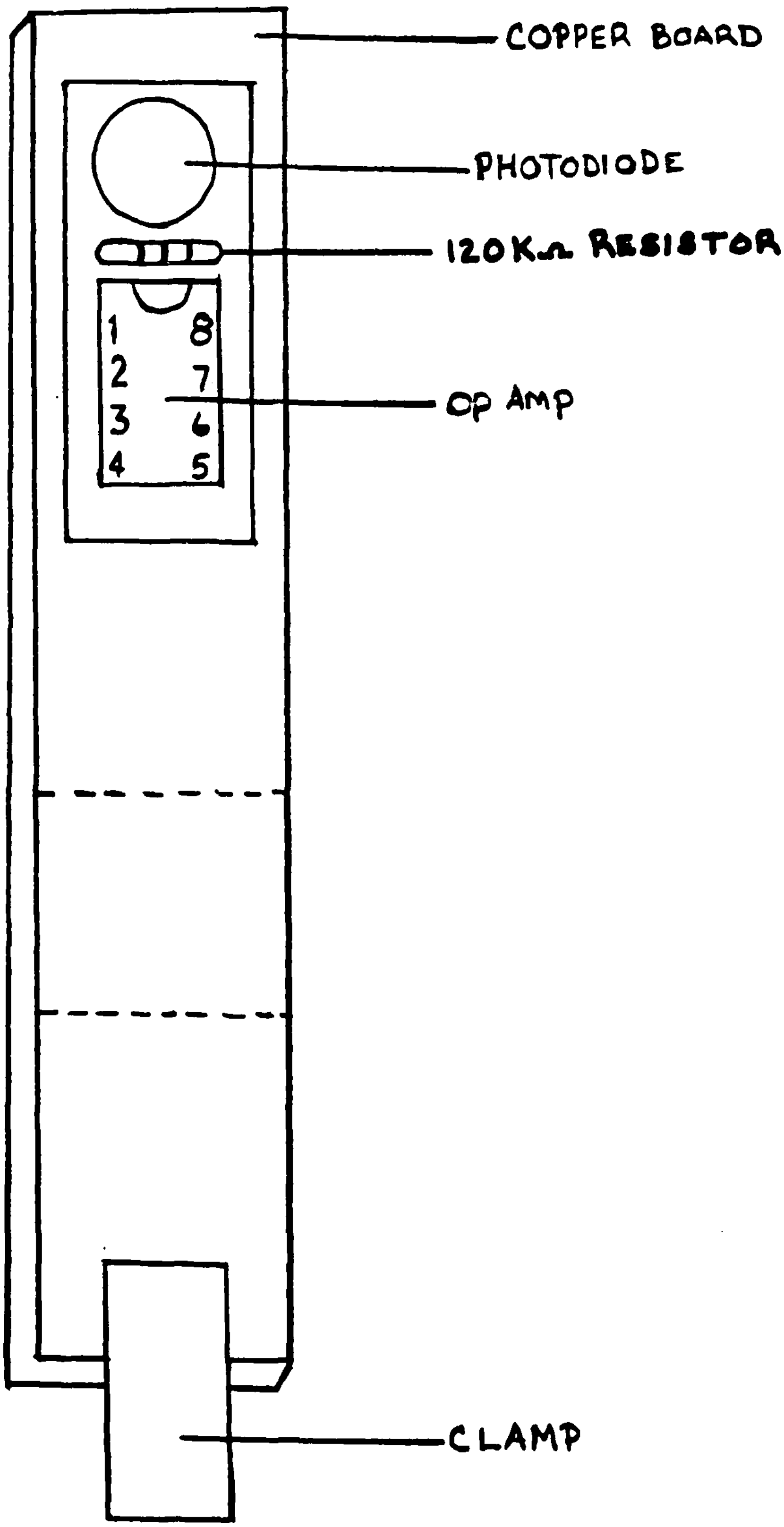


FIG. 3 Circuit

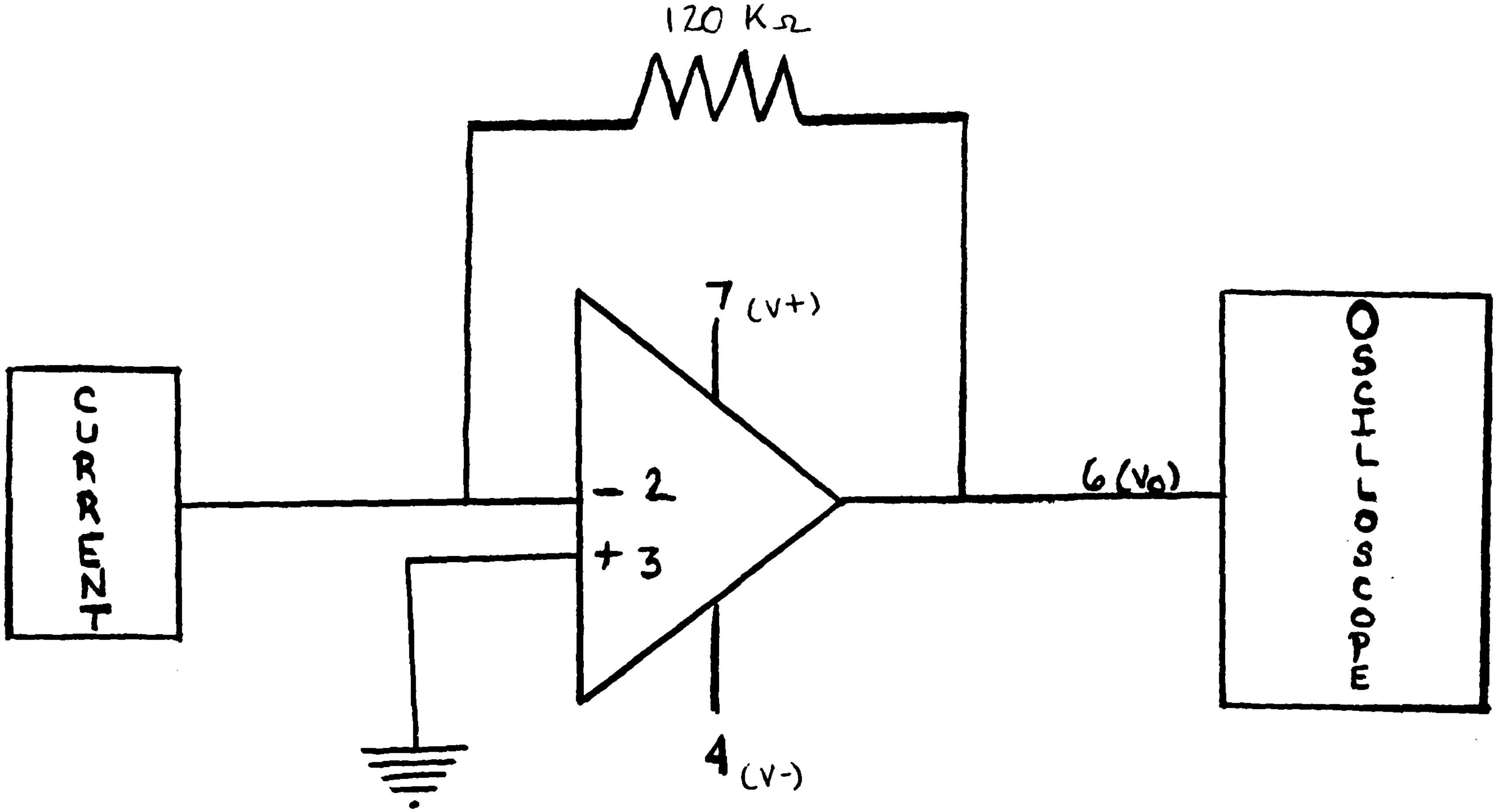
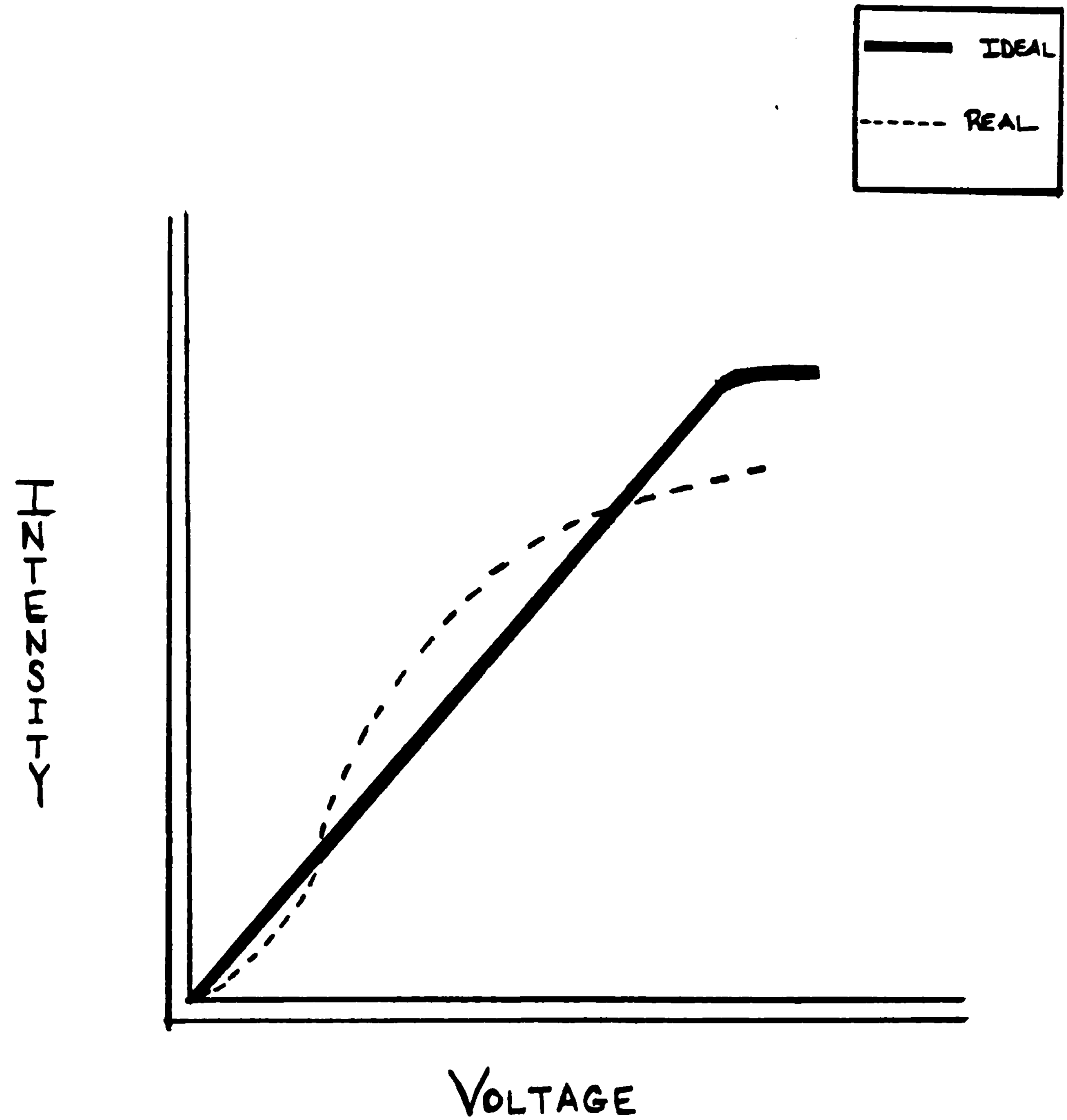


FIG. 4 Graph



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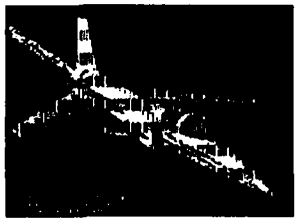
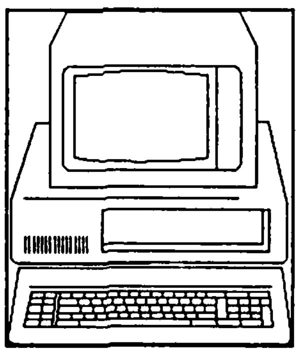
SCHOOL OF AEROSPACE MEDICINE



FINAL REPORT: APPRENTICE PROGRAM SUMMER 1989

JEANNE BARTON

USAF SAM/VNB
MENTOR: JONATHAN FRENCH



INTRODUCTION

When performing evermore demanding tasks under less than ideal conditions, the body is certain to find its own natural bounds. When challenged, these bounds may often fall dramatically short of the minimum task requirements. Without ways of increasing man's work potential, technology will be restricted to the physical limitations of the men who use it. For example, machines can operate 24 hours a day seven days a week; certainly far beyond human capacity. As society demands 'around the clock service' or as some military operations demand 24 hour readiness, the factors affecting physical bounds come under greater scrutiny.

Because many tasks require long, irregular hours, much research has been dedicated to sustained operations. One study I participated in during the Summer Apprentice Program dealt with "The influence of broad spectrum light on neuroendocrine responses and performance." This study attempts to use illuminance technology to minimize fatigue induced by sustained operations. This project will be the focus of the paper. (French and Hannon, 1989)

ACKNOWLEDGEMENTS

I would like to thank all the people who helped to make this apprenticeship educational and rewarding. Thank you to Universal Energy Systems for providing such an innovative opportunity. Thank you to the Air Force and to Brooks Air Force Base School of Aerospace Medicine for being such gracious hosts. The facilities available were exceptional. Thank you to Dr. Russ Burton for coordinating the entire program and ensuring that there was an appropriate laboratory for me to work.

I would also like to thank the individuals with whom I worked. Dr. Storm was very generous in allowing his branch (Aerospace Research Crew Performance) to host apprentices. Dr. Pat Hannon and Jeff Whitmore were gracious with their time and patience. I could always count on their help when anything went wrong.

Lastly, I would especially like to thank Dr. Jonathan French for spending countless hours helping me in my work. He always made sure that the work environment was pleasant and productive. He went out of his way to allow me to work on my own and learn for myself with the assurance that he was always nearby to help.

GENERAL DESCRIPTION OF RESEARCH

Melatonin is a neuroendocrine hormone found in animals that is thought to play a major role in enhancing sleep (Figure One). Following a natural circadian rhythm, the amount of melatonin circulating in the blood varies throughout the day. Recently, melatonin levels have been shown to be directly affected by bright wide spectrum illumination.

The purpose of this study was to determine if wide spectrum illumination (emitted by Vita Lights from DuroTest Corp.) can sustain melatonin suppression for extended periods of time. Both blood plasma and saliva levels of melatonin were taken throughout the 28 hour test period.

If intense wide spectrum illumination suppresses melatonin levels, the next logical question is: What effects do the lower melatonin levels have on fatigue and performance. By looking at twelve trials of performance and mood tests given throughout the experiment, this study attempts to discover if melatonin suppression reduces fatigue and enhances performance.

Because technology often pushes man to his physiological and psychological limits, any aid that improves performance with minimal side effects can be very beneficial. With the ability to phase shift circadian rhythms (primarily with light exposure), crossing time zones and shift work could be made easier for those involved. Not only would the individuals feel more comfortable, but they may also show improved productivity.

A knowledge of melatonin circadian rhythms can also be used in medical applications. The condition SAD (Seasonal Affective Disorder) has been shown to improve during treatment involving bright lights. Although these patients show symptoms of depression, they do not respond to normal drug treatment for depression. The SAD condition usually only appears during the winter months and corrects itself with light therapy.

METHODOLOGY

This experiment required ten male subjects without vision impairment. Subjects were required to refrain from stimulants and depressants for the 24 hours prior to the experiment. Because this research examined the effects of wide spectrum illumination, similar to natural sunlight, on circadian rhythms, the subjects were told to avoid excessive sun exposure and all outside recreational activities for the three days preceding the test.

Data analysis used a repeated measures design for performance measures with each subject participating in the test conditions of high intensity light (3200 lux) and low intensity light (100 lux) for one session each. The ten subjects were divided into two groups of five, and five subjects were evaluated each session. All lights were purchased from DuroTest Corp. To prevent the subjects from anticipating results based on the light condition and therefore performing differently under the two conditions, awareness of the conditions will be minimized by calling the bright light diffuse light and the dim light focused light. Beginning practice trials insured that stabilization of learning occurred and that any variance of performance was due to fatigue. Repetitive tasks and extended hours without sleep were used to the induction of fatigue.

During the test period, both performance and physiological data were collected at regular intervals. A computer test battery requiring several different skills provided performance accuracy and response time data. Electroencephalogram (EEG), electrooculogram (EOG), and electrocardiogram (ECG) recordings were taken at the end of each trial. Following these measures, 25cc of blood was taken through catheters located in the forearm. After blood samples were collected, heparinized saline (300 units) was injected into the catheter in order to prevent blood clotting. Each subjects was asked to give a 3cc saliva sample. Melatonin levels were assayed from plasma and saliva samples taken at the end of each trial.

All food for the subjects was monitored for consistency by the experimenters. Some restrictions of food applied. No caffeine or other stimulants was allowed throughout the test . This includes chocolate, coffee, and caffeinated soft drinks.

After organization, the data was processed on a Zenith 248 computer (AT class). WordPerfect 5.0 and Lotus 2.01 were used in final preparation of the data for statistical analysis. Analysis of variance procedures were then used to evaluate the groups' data.

The schedule of lighting conditions for groups one and two is shown in Table One.

The testing regimen for all subjects is shown in table Two.

RESULTS

Although all the final results will not be available for some time, some preliminary observations were made by noticing subject awareness and mood throughout the experiment.

Between 2:00 AM and 8:00 AM, subjects in both conditions seemed to grow tired and have less energy. They appeared less interested in the tasks presented to them. Subjects in the bright light condition felt less fatigued and did not appear to show the usual 3:00 AM lull but then felt most tired around 7:00 AM. The subjects in the dim conditions seemed more active around 7:00 AM and grew less tired than they had been throughout the night. This information seems to indicate that exposure to bright light can delay fatigue and performance degradation but cannot eliminate it for an extended period of time.

Because these results may be biased, it is best to withhold any conclusions until after statistical evaluation. However, in support of this observational data, preliminary analysis has revealed that in at least one cognitive test, the bright light improved accuracy and response time at one time point. As shown in Table Three, subjects in the bright light condition had fewer errors ($\bar{x} = 0.92$) and faster response time ($\bar{x} = 1.98$) than the dim light condition ($\bar{x} = 1.71$ and $\bar{x} = 2.81$, respectively).

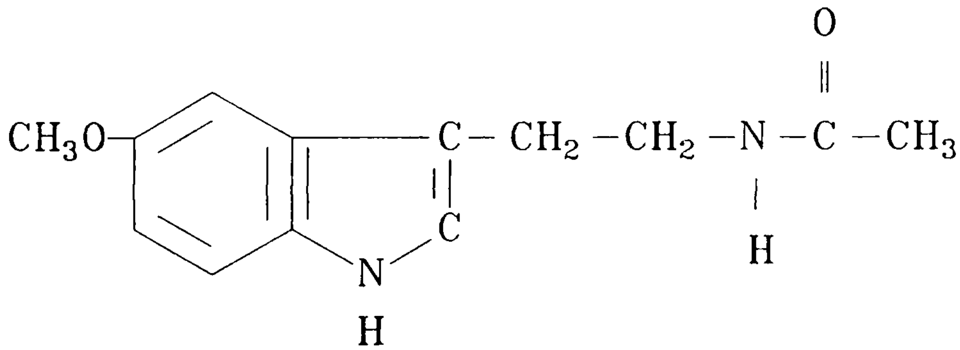


FIGURE 1. MELATONIN ($C_{13}H_{16}N_2O_2$)

(N–Acetyl–Methoxyserotonin)

Table 1

Lighting conditions and schedules for subjects during light induced melatonin suppression and fatigue study.

		Stabilize 0800-1600		Treatment 1600-0800	Duration 0800-1000		Duration 1000-1200
GROUP 1.	WEEK 1:	Dim	-	Dim	Dim	(Dark Adapt)	Dim
	WEEK 2:	Dim	-	Bright	Dim	(Dark Adapt)	Dim
GROUP 2.	WEEK 1:	Dim	-	Bright	Dim	(Dark Adapt)	Dim
	WEEK 2:	Dim	-	Dim	Dim	(Dark Adapt)	Dim

Dim = 100 lux measured from subject eye level
Bright = 3200 lux measured from subject eye level
Dark Adaptation will be performed individually in a separate room illuminated by at most 5 lux and will require only about 5 minutes per subject.

Table 2
SCHEDULE OF EVENTS

0700	Arrive in Lab 24x	
0800	Preparation for measurements	
1000	Trial 1 Performance and mood tests	
1045	Electrophysiological tests/ Blood saliva/temperature	
1115	MEAL	
1200	Computer role playing tasks-Practice	
1400	Trial 2 Performance and mood tests	
1445	Electrophysiological tests/ Blood saliva/temperature	
1515	Computer role playing tasks	SNACK
1600	Trial 3 Performance and mood tests	
1645	Electrophysiological tests/ Blood saliva/temperature	
1715	MEAL	
1745	LIGHT TREATMENT BEGINS	
1800	Trial 4 Performance and mood tests	
1845	Electrophysiological tests/ Blood saliva/temperature	
1915	Computer role playing tasks	
1945	MEAL	
2000	Trial 5 Performance and mood tests	
2045	Electrophysiological tests/ Blood saliva/temperature	
2115	Computer role playing tasks	
2200	Trial 6 Performance and mood tests	
2245	Electrophysiological tests/ Blood saliva/temperature	
2315	SNACK	
2400	Trial 7 Performance and mood tests	
0045	Electrophysiological tests/ Blood saliva/temperature	
0115	Computer role playing tasks	
0200	Trial 8 Performance and mood tests	
0245	Electrophysiological tests/ Blood saliva/temperature	
0315	Computer role playing tasks	SNACK
0400	Trial 9 Performance and mood tests	
0445	Electrophysiological tests/ Blood saliva/temperature	
0515	MEAL	
0600	Trial 10 Performance and mood tests	
0645	Electrophysiological tests/ Blood saliva/temperature	
0715	Computer role playing tasks	
0745	LIGHT TREATMENT ENDS	
0800	Trial 11 Performance tests and mood tests.	
0845	Electrophysiological tests/ Blood saliva/temperature	
0915	Computer role playing tasks	SNACK
1000	Trial 12 Performance and mood tests	
1045	Electrophysiological tests/ Blood saliva/temperature	
1115	Computer role playing tasks.	
1115	Dark Adaptation Test	

Table 3

Average results from the Mannequin test of cognitive abilities.

	LIGHTING CONDITIONS		
	FOCUSED	DIFFUSE	TIME POINTS
Number of errors	1.71	0.92*	Overall
Response time (milliseconds)	2.81	1.98*	0530 hrs
Time to complete task (seconds)	79.0	70.5*	2230 hrs
	89.3	76.5*	0530 hrs

* $p < 0.05$

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High School Apprenticeship Program

Whitney Brandt

Dr. Sarah A. Nunneley

11 AUG 89

I would like to thank all the people who assisted in making this one of the best summers I've ever had.

Dr. Sarah Nunneley
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Mr. Don Tucker
Mr. John Garza
Dr. Melchor Antunano
Sgt. Liz Staves
Dr. Steve Constable
Dr. Loren Myhre
Mr. Tai Chen

Summary

During the eight weeks I was at Brooks Air Force Base I participated in several activities. The main project I was invloved in was the use of the CorTemp Disposable Temperature Sensor. The reason for this project was to find an easy, accurate, and reliable way to measure core temperature. In this experiment I calibrated seven temperature sensors. During this experiment we used the CorTemp sensors in several different manners; the sensor was used as a rectal probe, swallowed by two subjects, and used in several lab tests. During these experiments several problems were observed. Some of these are the inaccuracy of the temperature reading, problems with the recorder, and general problems with the pill system. I wrote this paper with the advise of my co-authors.

Besides the CorTemp radio pill experiment I also learned other scientific procedures. The one I liked the most was the blood analysis. Since my future is in the field of science the ability to analyze blood could be helpful. Even though it was a daily procedure I still found it intriguing. I learned the procedures for the analysis hemoglobin, hermatocrit, chloride, and osmolality. I also helped in pipetting blood from a test tube into percloric acid and seperating serum from a blood clot.

Also while I was at Brooks I attened several of the experiments that were going on at the time. From this I have found the study of heat stress very interesting.

Along with the learning experience of the program I was also able to use the facilities around the base. I found the library most helpful. I was

able to find information on topics for Science and History Fair projects and articles for my personal enjoyment.

The most important idea that I learned during this program is that reasearch is not easy. I was able to experience first hand the processes a scientist must go through to complete a project. I learned several scientific procedures and ideas. I gained knowledge about designing an experiment, writing a protocol, getting it approved, the hardships of bad data, and writing the report. I think this knowledge will help me in the future. I hope I will be able to attend next year and inhance my scientific abilities even more.

Introduction

Physiologists who study stress effects on human subjects would like to find a simple, reliable, and accurate way to measure core temperature without the inconvenience of a wire directly connecting the thermal sensor to a readout device. Telemetry systems which transmit temperature were invented in the early 1970's (4), but the sensors were too large for human use. Miniaturization later allowed development of ingestable "radio pills" which were used in some studies (1,2,3), but accuracy remained a problem. Only recently has technology based on the space program allowed development of more accurate systems.

The sensor selected for this experiment was Human Technologies Inc., CorTemp Disposable Temperature Sensor - Cor-100. This system was selected because it uses ultra-accurate crystal based microcircuitry which the manufacturer claims will deliver temperature measurements with an accuracy of 0.1°C. Another reason for choosing the CorTemp system is because the subject swallows the sensor (pill), and wears an antenna belt which transmits the information to the ambulatory recorder. This differs from the conventional manner in which the sensor is directly connected to a readout device. While this pill system is being marketed for clinical applications we hoped that it would be accurate and useful in the USAFSAM Thermal Physiology laboratory and possibly in field experiments.

The tests involved 14 CorTemp Sensors (pills), an Ambulatory Recorder, an antenna belt, and an uncovered antenna with an extended cable. We also tested several cables for transfering data from the Ambulatory Recorder to a computer and a printer.

Methods

Seven CorTemp Disposable Temperature Sensors were calibrated in a constant temperature water bath, set at 35°C, 39°C, and 42°C. The engineer for Human Technologies Inc. suggested that our water bath may be emitting magnetic energy which would interfere with the transmission from the CorTemp system. To prevent this interference from the motor of the water bath, water was circulated from the water bath to a glass jar and back via plastic tubing. In the jar a *mercury-in-glass thermometer* and two different rectal thermistor systems were used to determine the temperature of the water. The two rectal thermistor systems that we used were Yellow Springs Instruments (YSI) and Squirrel. The thermistor systems and the thermometer were calibrated independently and read within a 0.1°C of each other over the range of 35-42°C.

To read data from the Ambulatory Recorder, we received cables for a printer and a Zenith 248. The printer cable worked well. After several unsuccessful attempts to transfer data with the Zenith 248 cable the company sent us another one. Which also did not work. Since then we have unsuccessfully tried three cables. Because of this we were forced to abondon the Z-248 and use an IBM-PC-AT for data processing.

In the first experiment in vivo, the CorTemp Sensor was placed alongside a rectal thermistor in a finger cot, which was tied closed and used as a rectal probe to measure core temperature. The subject put on the Chemical Defense Ensemble (CDE) and then walked on a treadmill in a temperature chamber until rectal temperature reached 39°C. The treadmill was then stopped and the subject undressed and cooled down. She then resumed walking on the treadmill in shorts. Several short tests were performed to locate the reason for a "weak signal" found during the two hour duration of the experiment.

Subject two also used the CorTemp Sensor as a rectal probe. During this experiment the subject walked on the treadmill, put on the CDE, tried various postural positions, and resumed daily activities. These tests were done to determine under what conditions the sensor could be used. This experiment lasted three hours.

In the next experiment subject two swallowed a CorTemp Sensor. During this experiment a thermistor was used to measure rectal temperature. The subject went about daily routines along with walking on the treadmill to vary the temperature readings. This experiment lasted six and half hours.

The final experiment also involved swallowing the temperature sensor. Subject one dressed in the CDE and used a rectal thermistor. She then walked on a treadmill in a temperature chamber. During this experiment the subject walked for forty minutes and rested for twenty minutes while drinking water. When this experiment was completed the subject changed clothes and continued to monitor her temperature. She ate lunch and drank coffee to determine if any change would occur. The subject stopped monitoring temperature after about three hours.

Results

During the calibration process one pill had a tear in the outer coating which exposed the battery. This allowed water to damage the internal mechanism that determines the temperature. The other six sensors read 0.7-1.0°C high compared to the thermometer and the rectal thermistor systems (Fig. 1) Although there was an offset it was constant and linear. Several reasons for this offset have been suggested and tested. It was hypothesized that the metal table on which the jar was placed was causing magnetic interference. However when the jar was placed in the middle of the room, twenty-six inches away from any metal object, the sensor still read high. It was also assumed that the rectal thermistors in the water near the pill might be influencing the signal, but when they were removed there was no effect on the pill reading. Also during the calibration process it was observed that the sensors had a short temperature range, 35-45°C. A more accurate calibration could be performed if there were a wider temperature range. In addition, clinical and experimental data from human subjects mandate a range from 25-50°C.

During the experiments in vivo the CorTemp sensors still read high and several other problems were also observed (Fig. 2). If the person using the sensor sat down, leaned against a metal wall, or was lying on a metal floor, the signal from the sensor would be weak and the reading not reliable. The CDE used in these experiments contains a lining of charcoal particles. It was thought that this could be interfering with the signal from the sensor, but when the garments were put on and off, there were no detectable effects on the pill readings. Data analysis was made difficult by the timing algorhythm in the Ambulatory Recorder, since repeated readings caused various offsets in the timing record (Table 1). False readings were also a major problem (Table 1 and Fig. 2). When the data were transferred to the IBM-PC-AT and the raw data were examined, at least a third of the readings were inexplicably high or low (Table 1). Another problem was that many of the output readings from the receiver would be "no reads", meaning the sensor was unable to take a temperature reading. Thus occured for no obvious reason, since "no reads" occurred while a subject was just sitting in an air conditioned room. Also, when the temperature sensor was used with a subject, the readout appeared to be extremely sensative to the sensor-antenna relationship. Almost every reading was either weak or there was no reading at all. Another problem with the antenna was the size. It was too large for our subjects to use and the velcro straps were too long. In addition, the event marker was unreliable. During the experiments when events would occur we would press the event marker and the box would respond by requesting an event number, but many of these events failed to appear on the printed data sheet. The manufacturer unequivocally stated that the Ambulatory Recorder must be used with a Kodak Lithium batteries to assure adequate operational duration. When we inserted such batteries the recorder gave a battery low indication. We were forced to operate with conventional batteries. Despite the knowledge that they would sustain operation for less than 24 hours. Human Technologies Inc. was unable to explain or correct this problem.

When the recorder is running depressing any botton stops data collection. Resumption requires complex and repeated data entry. The recorder keyboard is flat and unguarded so that accidental stops are relatively common during ambulatory experiments causing unexceptable loss of data.

Conclusions

The following summarizes significant problems which we encountered with the CorTemp system:

1. Battery Life. The recorder would not run on the recommended lithium batteries, while conventional batteries have too short a life.
2. Temperature offset. All of the tested sensors had an offset of 0.7-1.0°C both in vitro and in vivo. This casts doubt on the HTI calibration process or the recorder's signal processing; we were unable to resolve this discrepancy.
3. Antenna size. The antenna belt received was oversized for our subjects and the velcro straps were too long.
4. Loss of signal and false readings. Data collected from ambulatory subjects were characterized by significant numbers of readings which were incorrect or off scale.
5. Event marker. The markers often failed to appear with the data, even though the real-time readout had indicated no problem.

6. Data timing. The "dump to printer" feature simply deleted doubtful readings, while the computer files often included several (erroneous) readings per recording interval. In either case, the data had to be hand-processed to produce a meaningful time-temperature plot which could be compared to other data records.
7. Recorder stop. it was too easy to accidentally stop data collection, and too hard to resume. The keyboard needs guarding and the software should be modified to allow quick correction of an error.
8. Interference. A wide range of factors appear to block the signal or cause erroneous readings. These problems need to be better defined and should be given to potential users.
9. Temperature range. The current temperature range (35-45°C) is too narrow for either clinical application or physiological studies. A preferable range would be 25-50°C.

The results of this experiment were disappointing, since we hoped to find a rugged system capable of 0.1°C accuracy. The temperature offset can probably be resolved, but the numerous other malfunctions render this system unacceptable for data collection in our experimental environment.

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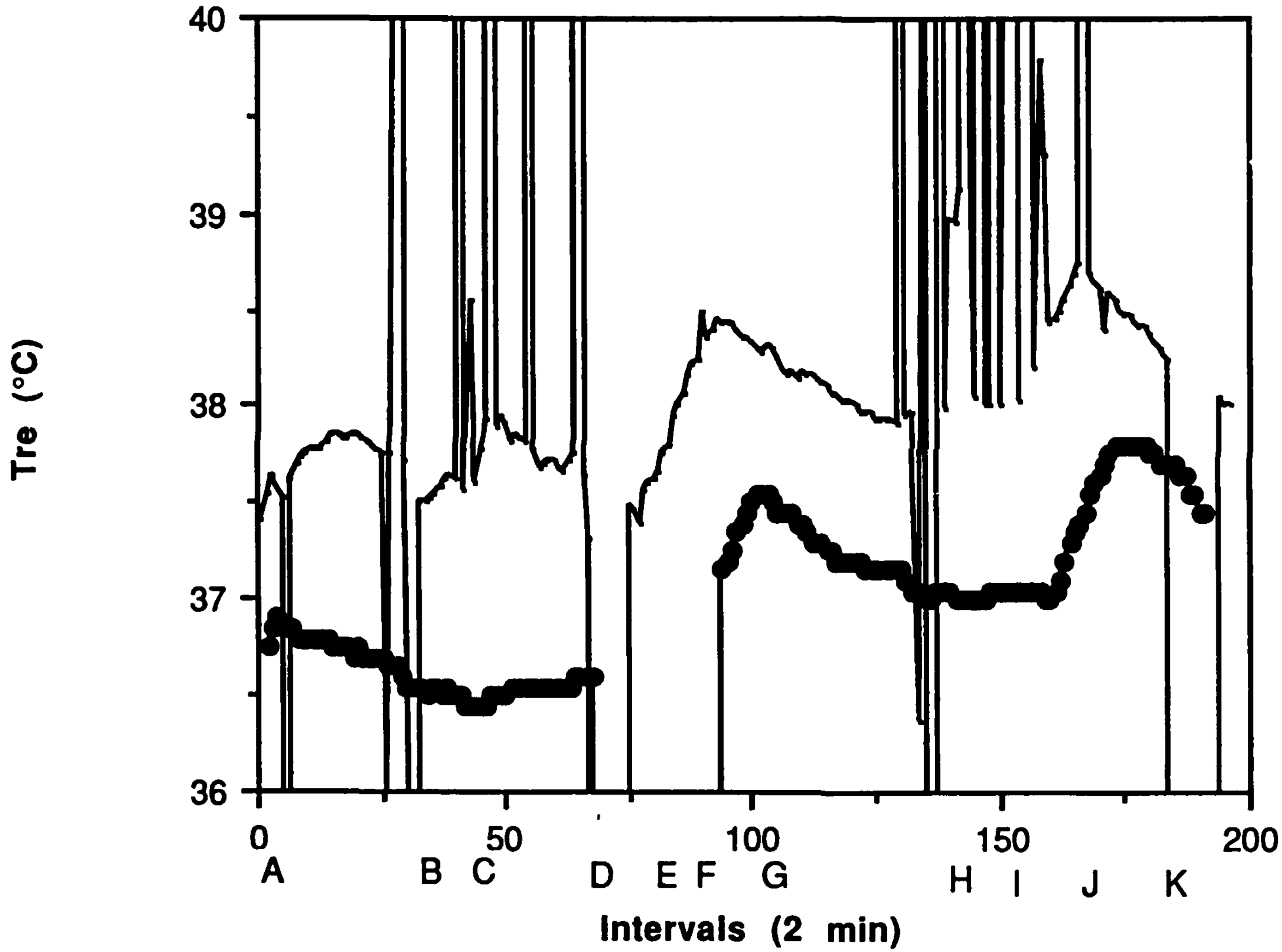
Table 1. This data was taken on 28 Jul 89 from subject two. Column one is a list of codes used to identify errors. The center column is the time of day at which the reading took place. For this experiment 30 second intervals were used. During this time period the subject was recovering from a bout of exercise and was walking outdoors. Note that some times are repeated more than twice while others are only done once. The last column is the temperature. In just 8 minutes the recorded temperature ranged from 4.68 to 76.32.

Code	Time	Pill Reading(°C)
T00	09:50	38.17
T00	09:50	38.18
T00	09:51	38.17
T00	09:51	38.20
T00	09:52	59.96
C08	09:52	76.32
C08	09:53	4.68
C08	09:53	06.58
T00	09:53	72.26
C08	09:54	38.15
T00	09:55	38.14
T00	09:55	75.50
C08	09:55	44.02
C08	09:56	38.13
T00	09:57	38.13
T00	09:57	38.13
T00	09:58	38.12
T00	09:58	38.12

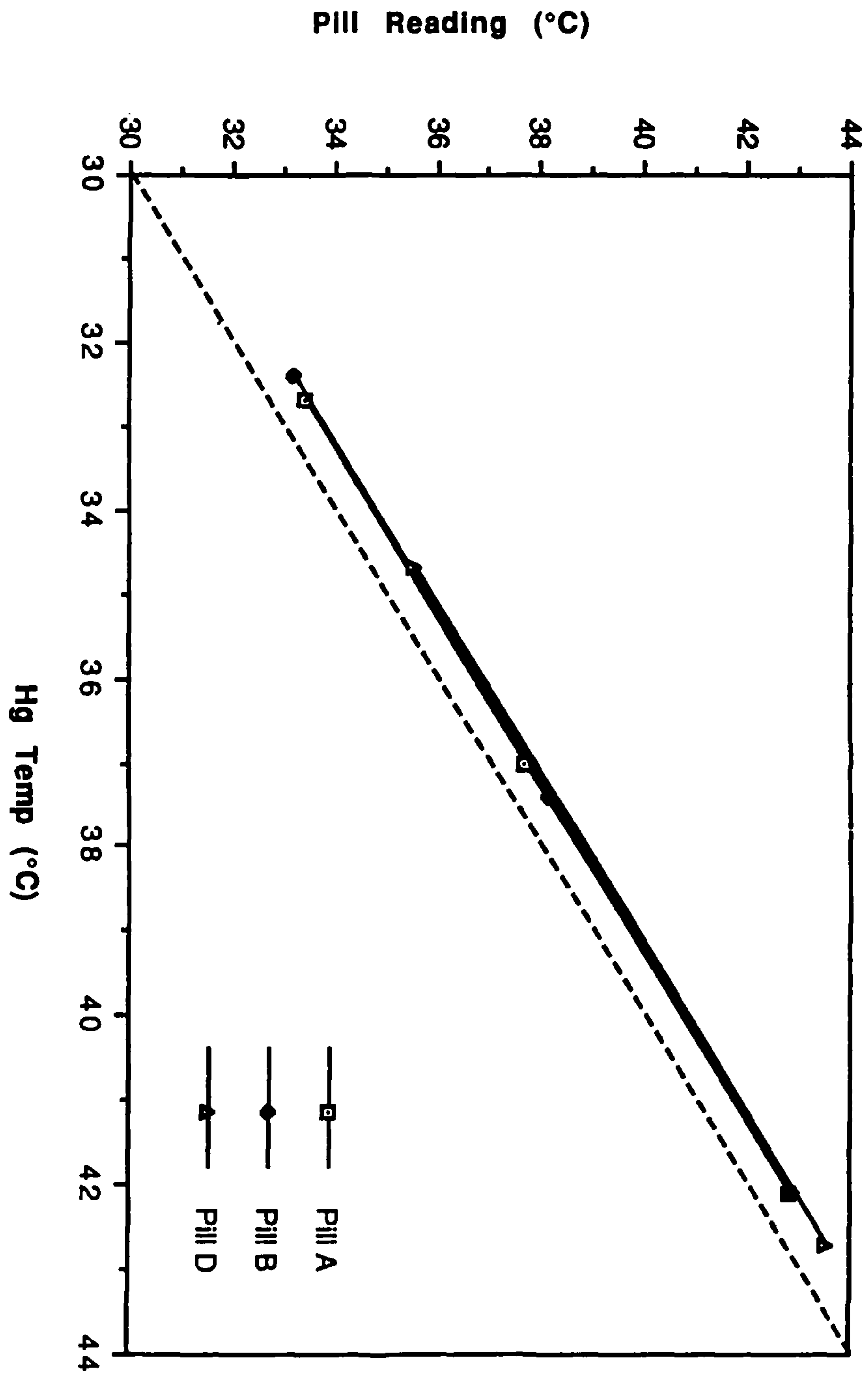
Captions

Fig. 1. Readings from three CorTemp sensors compared with the line of identity. All three pills read 0.7-1.0°C high compared to the thermistor systems and the thermometer.

Fig. 2. This graph represents a comparison between a CorTemp sensor (-) and a rectal thermistor (•). The letters at the bottom represent events that occurred during the course of the experiment: A-start, B-walk to chamber and back, C-cup of coffee, D-change clothes; antenna removed, E-start walking on treadmill, F-stop walking on treadmill, G-went off base, H-drank tap water and hot soup, I-start walking on treadmill, J-stop walking on treadmill, K-change clothes; experiment ended. Fig. 2 shows that the CorTemp sensor had several off scale readings during the duration of the experiment.



Tre (°C)
40
39
38
37
36
0
50
100
150
200
A
B
C
D
E
F
G
H
I
J
K
Intervals (2 min)


Pill Reading (°C)
30
32
34
36
38
40
42
44
Hg Temp (°C)
Pill A
Pill B
Pill D

ELECTRICALLY AND CHEMICALLY INDUCED RELEASE OF L-GLUTAMATE FROM HIPPOCAMPAL MOSSY FIBER SYNAPTOSOMES

CHRISTINA A. CHENEY

DR. DAVID TERRIAN

NEUROSCIENCES(NGNS)

AUGUST 11,1989

I. ACKNOWLEDGMENTS

Everyone I have come in contact with this summer has added to the wonderful experience of the last eight weeks and deserves to be recognized. I owe a special thanks to Universal Energy Systems for overseeing this program which has given me the exciting opportunity to work in a research laboratory this summer. My mentor, Dr. David Terrian, and his assistant, Dr. Robert Gannon, have been incredible teachers. They gave me the books and pamphlets to read and patiently answered all my questions. Without their patient guidance my frustration, caused by ignorance, would have overwhelmed me. I am also grateful to the people in the Neurosciences function. They offered suggestions and advice that helped my work this summer to be smooth and pleasant. The research assistants in the lab, Peter Hernandez, Anne Marie Michel, and Sudar Alagarsamy, taught me how to use various types of equipment and were always ready to answer my questions. I am also grateful to Dr. Burton, the Chief Scientist at the Air Force School of Aerospace Medicine, who was actively involved in this summer program and willing to help whenever necessary.

II. General Description of Research

The summer apprenticeship program sponsored by Universal Energy Systems is an excellent way to increase ones' understanding of and interest in science. This summer I assisted in a neuroscience research laboratory. I did everything from washing dishes to running experiments to calculating results. The first couple of weeks I studied a physiology book which helped me gain a general understanding of the field I would be working in. However, most of what I learned came through hands-on experience. This program has not only given me the opportunity to expand my knowledge in the neurosciences, but also to other fields of science.

The ultimate goal of the research conducted by my mentor, Dr. David Terrian, is to acheive a better understanding of Alzheimer's disease and epilepsy, leading to improved treatments for these disorders. Both epilepsy and Alzheimer's disease are thought to be caused by an imbalance between excitatory and inhibitory neuro-transmitter substances released by neurons in the central nervous system. The seizures in epilepsy are due to continual, uncontrolled firing of neurons, whereas memory loss in Alzheimer's disease is thought to be caused by either the death of neurons or the reduction of transmitter substance released by them. Dr. Terrian, therefore, has concentrated his studies on controlling the release of glutamate, a dominant excitatory transmitter substance.

Dr. Terrian performed two types of experiments to try to inhibit or induce glutamate release. In his experiments he used hippocampal mossy fiber synaptosomes isolated from rats or guinea pigs. One series of experiments focused on electrical stimulation of glutamate release from the mossy fiber synaptosomes, while the other series of experiments evaluated different drugs as inhibitors or stimulators of glutamate release from the mossy fiber synaptosomes.

III. Methodology

The electrical stimulation experiment required the use of such equipment as a fraction collector, a superfusion pump, a stimulator-isolator, an oscilloscope, and a custom-designed chamber to hold the tissue and facilitate electrical stimulation. Inside the chamber were placed a filter paper, a buffer solution, the tissue (containing hippocampal mossy fibers synaptosomes), and some strands of glass wool to support the tissue. The chamber was connected to the stimulator-isolator and to the superfusion pump which allowed a buffer solution to continually run through the chamber. The outflow from the chamber was connected to a fraction collector. We could then collect timed fractions of the buffer solution and see if any glutamate had been released from the synaptosomes into the solution.

The tissue would be stimulated for a period of time (time was varied in different experiments) followed by a period of rest. In general, the tissue would be stimulated electrically four to five times in an experiment. In different trials, various frequencies and stimulation lengths were tested.

In other experiments, neurotransmitter release was evoked by raising the concentration of potassium ions in the superfusion solution. It was demonstrated that a high potassium concentration (35mM) would stimulate glutamate release from the mossy fiber synaptosomes. Therefore, the last fraction in this experiment is stimulated with a dose of high potassium. This way we can compare results of the unknown effects of the electrically stimulated fractions to the known effects of potassium stimulations. By using the high potassium solution we could insure that the synaptosomes maintained membrane potential by measuring the amount of glutamate released in response to potassium-induced depolarization (Figure 1).

Another experiment Dr. Terrian performed used drugs and chemicals to suppress or induce glutamate release from hippocampal mossy fiber synaptosomes. The main equipment used in this experiment was a fraction collector and a superfusion pump. Connected to the superfusion pump were twelve columns. Each column contained a filter, sephadex gel(G25), the tissue, more sephadex, another filter, and a buffer solution. We usually collected six four-minute fractions from twelve columns simultaneously. At various times during the experiment different drugs would be used to inhibit or induce glutamate release from the tissue. The most frequently tested drugs were quisqualate, kainate, and 6-cyano-7-nitroquinoxaline-2,3-dione(CNQX). In the latter part of the summer this type of experiment was also used to test for presynaptic receptor sites.

A low potassium solution was used as a control in the chemical stimulation experiment. The low potassium solution acted as a physiological control because it did not react with the tissue to alter glutamate release. Thus, it could be used as a baseline in comparing how different drugs affect the mossy fiber synaptosomes. If the drug was an inhibitor, the amount of glutamate released would be less than that in the low potassium fraction, whereas if the drug were an inducer, the amount of glutamate released would be more than that in the low potassium fraction. Once the experiments were completed and the fractions collected, we assayed the glutamate content. This was done using the glutamate assay of Graham and Aprison (1966) based on the reduction of NAD by glutamate dehydrogenase (GDH) according to the formula:

$$\text{glutamate} + H_2O + NAD^+ \overset{\text{GDH}}{\rightleftharpoons} \alpha\text{-ketoglutarate} + NH_4^+ + NADH + H^+.$$

The amount of NADH produced is in a direct ratio with the amount of glutamate in the sample. We determined the amount of NADH produced by measuring its fluorescence on a Luminescence Spectrometer. Thus, by measuring how much NADH was produced we could calculate the amount of glutamate in a sample.

To prepare the assay, we first set up a standard curve. This consisted of eleven tubes containing known amounts of glutamate. Three of the tubes were blanks, and duplicate tubes contained 500, 1000, 2500, or 5000 pmoles of glutamate. Each tube, whether it was a known or unknown sample, was taken through the same procedure. We added NAD to the sample and recorded the fluorescence. Next we added the GDH to the sample and let it incubate for thirty minutes (this is the reaction time required to approach equilibrium). Then we recorded the fluorescence of the sample again. After this was completed, some simple formulas and calculations were all that were needed to find the glutamate concentration of the sample. With this data we could then determine the experimental results.

IV. RESULTS

The results obtained from the electrical stimulation experiments proved to be inconclusive and those experiments were discontinued in the middle of the summer. Complications arose due to the buffer solution changing pH levels as a result of CO_2 production elicited by the electrical current passing through the platinum stimulating electrodes. As a result, the tissue was probably stimulated by the pH change rather than the electrical current. Nevertheless, Dr. Terrian will continue research in this area this fall.

The second series of experiments which employed high potassium to chemically induce the release of glutamate were more successful. We determined that nanomolar concentrations of the glutamate agonist quisqualate would depress the release of glutamate from the mossy fiber synaptosomes in response to the potassium stimulation. Furthermore, this depression was prevented by low micromolar concentrations of the quisqualate antagonist CNQX. This is the first evidence of an inhibitory presynaptic quisqualate receptor on hippocampal neurons, as well as the first pharmacological evidence for any type of inhibitory glutamatergic receptor on a hippocampal mossy fiber terminal.

V. Further Observations

This summer has truly been a learning experience. Not only have I had the chance to work in Dr. Terrian's laboratory, but I was able to visit other labs at the Air Force School of Aerospace

Medicine. I also had the privilege to attend several lectures given by scientists at the School which have increased my knowledge and interest in several other scientific areas.

Through the apprenticeship program, I have gained experience in a work environment. This includes the mentor/apprentice relationship, sharing office space, working with others in a laboratory, employee relationships, and the concept of the amount of work that is nesessary to successfully complete a research project. I have met other high school students, college students, and research scientists, some have become my friends and many shared their advice on my work, schooling, and jobs to come. This summer has truly been an enjoyable and memorable experience.

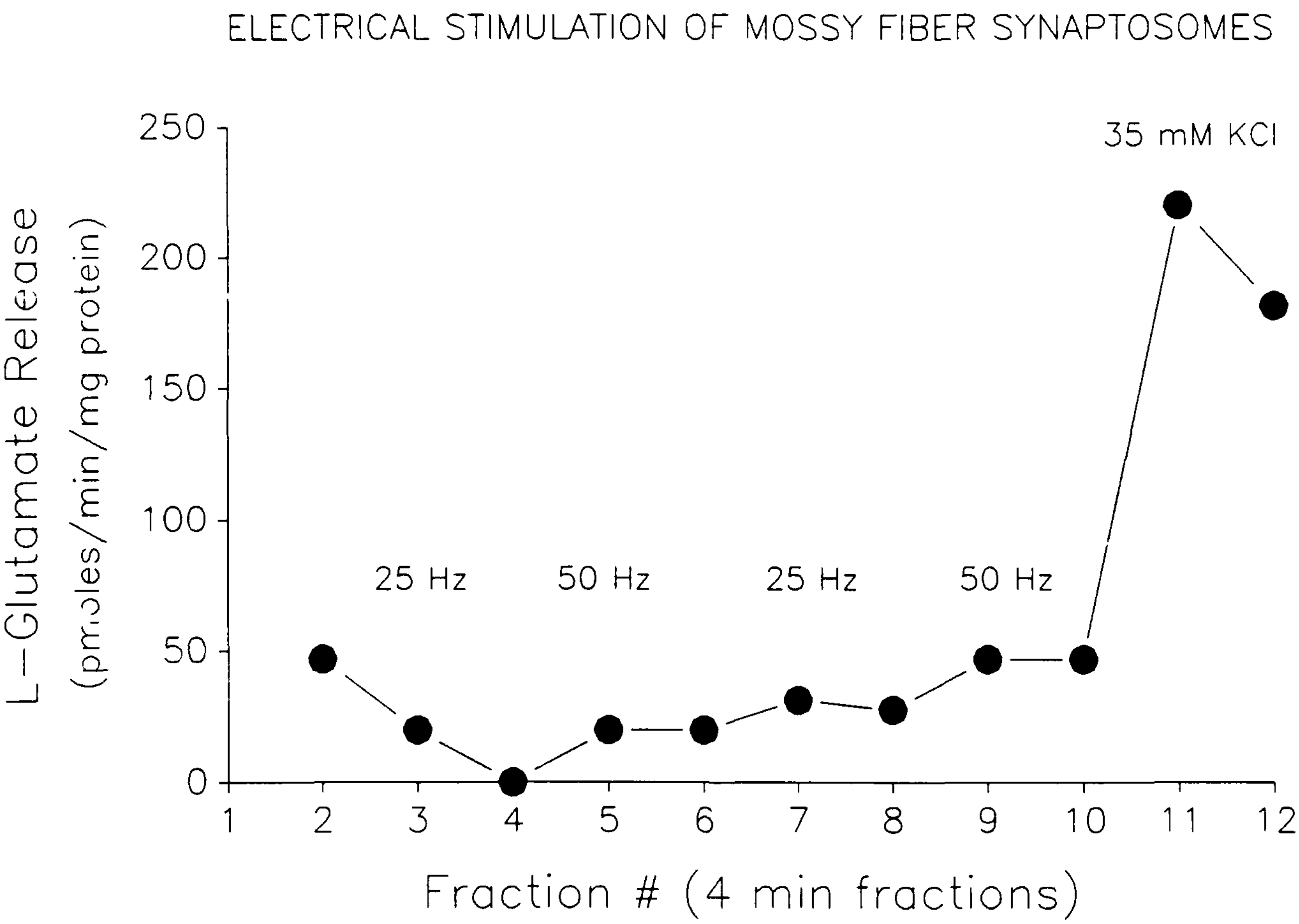


Figure 1. Example of the paradigm used for the electrical stimulation of mossy fiber synaptosomes. In this experiment the first pair of stimuli were 10 ms biphasic pulses of 2 volt intensity. The second pair of stimuli were 20 ms biphasic pulses of 2 volt intensity. At the end of each experiment a 4 min application of 35 mM KCl was delivered to demonstrate tissue viability.

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FINAL REPORT

DETERMINATION OF RESTRICTION ENZYME PATTERNS OF RAW DNA WITH BIOTINYLATED PROBES TO HEAT SHOCK PROTEIN AND TUMOR NECROSIS FACTOR

Prepared by:	BRIAN G. McBURNETT
Academic Rank:	HIGH SCHOOL SENIOR
School:	SAMUEL CLEMENS HIGH SCHOOL
Research Location:	BROOKS AFB
	SAM/RZP
	SAN ANTONIO, TEXAS 78235
USAF Researcher:	JILL E. PARKER, PH.D.
Date:	AUGUST 11, 1989

ABSTRACT

Deoxyribonucleic acids (DNA) extracted from mouse macrophage RAW 264.7 cells were used in this study. BamH I, EcoR I, Msp I, Pst I, and Pvu II were used to digest the DNA. The digests were then run on a gel and Southern blotted to nitrocellulose. The blot was hybridized with biotinylated probes to heat shock protein (HSP), tumor necrosis factor (TNF), and Abelson leukemia virus (v-alb 1, and v-alb 2). Different patterns were obtained and their intensities and positions were noted for future reference.

INTRODUCTION

This study was conducted during the past eight weeks under the direction of Dr. Jill Parker in Dr. Johnathan Kiel's laboratory. The project assigned was to establish a baseline for further research in the laboratory.

In the Radiation Sciences Physics Branch at Brooks Air Force Base (RZP), RAW 264.7 cells are used routinely in the presence of various concentrations of lipopolysaccharide (LPS) alone, or in combination with 3-amino-L-tyrosine (3-AT). RAW 264.7 is a mouse (BALB/c) macrophage transformed with Abelson leukemia virus (Raschke et. al., 1978). These cells have been observed to release TNF which is sensitive to LPS, and were chosen to be studied because of this property.

TNF is a protein with a wide range of biological activities. It is produced mainly by macrophages and is capable of killing transformed cells (Beutler et. al., 1985). Heat Shock Protein was also chosen as a probe because of its properties. HSP can be turned on by chemical or thermal parameters (Wu et. al., 1986). In this study a baseline was to be established at 37^{O}C. Later studies will be processed at higher temperatures. The HSP probe was a gift from Dr. J. Nevins, Rockerfeller University; the TNF probe was a gift from Chiron Corporation, California. Probes v-albI and v-albII (Srinivasan et. al., 1981) were chosen because of recent studies by Dr. Blystone (personal communication) suggesting that a virus may be given off by the RAW cells.

BamHI, EcoRI, MspI, PstI, and PvuII were the restriction endonucleases enzymes used in this study. They will produce a large variety of cuts. All of these enzymes have unique sequences and their fragment sizes are relatively large.

All of the materials were chosen in order to be compatible for comparison with the research in RZP.

OBJECTIVE

This was a basic research experiment conducted to formulate a standard for ongoing research. The DNA was extracted form the untreated cell in order to be used as a control group for further experiments. The results will then be compared to DNA extracted from RAW cells treated with LPS or LPS and 3-AT.

MATERIALS AND METHODS

All of the procedures were recieved from Dr. Parker and were used routinely in the laboratory.

DNA EXTRACTION

DNA was extracted from the RAW 264 cells in accordance with the procedure (Bell et. al., 1981). The procedure has been modified since bacteria were used instead of blood.

1. Wash confluent RAW 264.7 cell layer twice with Phosphate buffered saline (PBS). Add 10 ml of lysis buffer (.32M Sucrose, .01M Tris-HCl pH 7.5, .005 Magnesium chloride, 1% Triton X-100). Scrape cells from flask. Rinse cells from flask with up to 50 ml of lysis buffer.

2. Allow cells to sit in lysis buffer for 15 minutes at $4^{o}C$.

3. Spin cells at 2,700 rpm for 10 minutes. Pour off supernatant.

4. To nuclear pellet add 4.5 ml 0.075M Sodium chloride (NaCl) and 0.024M Disodium ethylenediamine tetracetic acid (EDTA) pH 8.0. Break up pellet gently. Add 0.5 ml of 5% SDS solution and 100 ul 10 ug/ul proteinase K solution.

5. Mix well and leave at $37^{o}C$ overnight.

6. Add to solution 5.0 ml phenol equilibrated with 20mM Tris-HCl pH 8.0. Shake vigorously and add 5.0 ml chloroform/IAA (isoamyl alcohol) 24:1. Shake again. Spin 10' at 2,700 rpm.

7. Remove upper layer to clean tube and repeat chloroform extraction.

8. Remove upper layer to a clean tube. Add 1/10 volume 3M Sodium Acetate (Na_2Ac) and 2 volumes of ice cold ethyl alcohol (EtOH). Invert tube back and forth until DNA falls out.

9. Remove DNA with hooked pasteur pipette and dissolve in 500 ul DNA buffer (10mM Tris Hcl pH 7.5 and 1mM EDTA).

10. Allow to dissolve at least overnight. Read concentration at 260 nM by dissolving 10 ul of this solution in 990 ul of DNA buffer.

Digestion of DNA

Extracted RAW chromosomal DNA was subjected to a 100 ul digest with each of the five enzymes. Each restriction enzyme has an unique salt requirement for optimum activity and this is indicated by using either buffer mixture, 2 or 3, as shown in the parentheses below. (DTT - Dithiothreitol, BSA - Bovine serum albumin)

	DNA	DTT	BSA	10xBuffer	Enzyme	H_2O
BamHI	7 ul	10 ul	10 ul	10 ul (3)	2 ul	61 ul
EcoRI	7	10	10	10 (3)	2	61
MspI	7	10	10	10 (2)	2	61
PstI	7	10	10	10 (2)	2	61
PvuII	7	10	10	10 (2)	2	61

The digests were then left at 37^{o} for approximately 2 hours. In order to see if the digest were complete a mini gel was run. 25 ml TAE (0.04M Tris Acetate, 0.001M EDTA) and 0.25 g agarose were combined and heated over a burner until they dissolved. After the mixture had cooled slightly, 2 ul of Ethidium bromide (EtBr) was added and the gel was poured. 3.5 ul of DNA from each of the digests were combined with 5 ul of DNA gel dye and the tubes were set aside. Once the gel had solidified, 8.5 ul of the solutions were added to each well. The gel was then subjected to electrophoresis at 100 volts for about 1 hour. After the digests were observed to be complete, by viewing on the transilluminator, they were ethanol precipitated in TAE. After precipitation, the pellets were spun and dried. The pellet was redissolved in 20 ul of DNA buffer. After the addition of 10 ul of DNA dye to each sample, the samples were run in duplicate (Ex. abcde|abcde), 15 ul per lane on a 0.8% agarose gel. The procedure for a Southern blot was then followed.

Southern Blot

1. Ran gel (25 volts overnight). Observed migration on transilluminator.

2. Took photo of gel with ruler. Notched one side of gel and notched across top for future identification.

3. Denatured gel in 0.5N Sodium Hydroxide (NaOH)/1.5N NaCl for 15' to 30 minutes. Changed solution and denature a further 15' to 30 minutes. Gel should be in a solution on a shaker with gentle agitation.

4. Neutralized gel with 0.5N Tris pH 7.0/1.5N NaCl. Two washes 15'to 30 minutes each on the shaker.

5. Flipped gel. (used plastic sheet for support)

6. Assembled baking dish with scintillation vial caps to support a glass plate.

7. Placed a piece of Whatman 3MM over entire plate so that touches bottom of baking dish on all 4 sides to act as wicks.

8. Cut two pieces of 3MM the size of the gel and placed on top.

9. Placed gel on 3MM paper.

10. Cut nitrocellulose filter the size of the gel and wet in 2xSSC (1x = 0.15M NaCl, 0.015M Sodium citrate). When wetted placed in 20xSSC.

11. Overlaid gel with nitrocellulose. Marked nitrocellulose with lane location.

12. Placed 2 pieces of Whatman 3MM cut the size of the gel or slightly smaller on top of nitrocellulose.

13. Cut paper towels slightly smaller than the gel and filter so that do not overhang and touch liquid or lower filter.

14. Placed on top of Whatman 3MM and place a weight on top. (agarose gel former makes a good weight)

15. Poured 20xSSC into baking dish and left overnight.

16. Removed paper towels. Cut filter in half while still wet.

17. Peel off filter and wash with 2xSSPE (1x = 1mM NaEDTA, 10mM Sodium dihydrogen phosphate, 0.18M NaCl, pH 7.0) or 2xSSC. Dried. Bake in Vacuo at 80 degrees for 2 hours to bind DNA.

18. Gel may be stained with EtBr and viewed to see if DNA transferred.

Probes for HSP and TNF were then started. Prepared plasmid as according to Dr. Parker's notes from Maniatis et. al. (1982).

<u>Preparation of plasmid DNA using M_9 medium</u>

E. coli HB101 transformed with plasmid DNA containing fragments of DNA from TNF, HSP and v-alb 1 or v-alb 2 were kept in continuous culture by streaking on to LB plates containing antibodies and passaging monthly.

To prepare large quantities of plasmid DNA from the positive clones a tube containing 2.0 ml of LB broth + antibodies was inoculated with one clone and grown with shaking overnight at 37°C.

Next day the culture was poured into 300 ml of sterile M_9 medium and left shaking at 37° until the optical density (OD) of the solution has reached between 0.6 and 0.9. Read at OD^{600}.

(NH_4Cl - Ammonium chloride, KH_2PO_4 - Potassium monophosphate, Na_2HPO_4 - Sodium diphosphate, $MgSO_4$ - magnesium sulfate)

M_9 medium	250ml	500ml	1l	2l	2.5l
NH_4Cl --------	.25 g	.5 g	1 g	2 g	2.5 g
KH_2PO_4 -------	.75 g	1.5 g	3 g	6 g	7.5 g
Na_2HPO_4 ------	1.5 g	3.0 g	6 g	12 g	15 g
NaCl ---------	.125 g	.25 g	.5 g	1 g	1.25 g
10% Casamino - Acids	.5 g	1 g	2 g	4 g	5 g

Autoclave

Sterile Stock	0.01M $MgSO_4$	(1M $MgSO_4$ stock)	10ml/l	2.0 ml
Sterile Stock	0.5% glucose	(50% stock)	10ml/l	2.0 ml
Antibody	5 ug/ml TET 15 ug/ml AMP	(10 mg/ml TET)	500 ul:10ug/ml	

Add $MgSO_4$, glucose and TET to autoclaved solution.

Remove 3.0 ml medium for blank.

Once OD has been reached add to each flask 10 ug/100 ml solution of chloramphenicol in 1.0 ml of ethanol. This stops cell replication, but lets plasmid DNA replication continue.

Cultures were left to replicate overnight.

Plasmid DNA

1. Poured cells into large sterile 500 ml plastic bottles and spun in Sorvall at 5,000 for 20 minutes to precipitate cells.

2. Dissolved pellet in a total of 8.5 ml 25% sucrose 0.05M Tris pH 8.0. The pellet was dissolved in 4.0 ml of sucrose solution and transferred to a sterile 250 ml Erlenmeyer flask. The bottle was washed out with an additional 4.5 ml sucrose solution.

3. To each flask added 1.7 ml of freshly prepared lysozyme. (5 ug/ml in 0.25M Tris pH 8.0) Wait 5 minutes and then add 4.8 ml Na_2EDTA 0.25M pH 8.0. Observed lysis. As solution appeared to thicken added 15.0 ml of 10% Triton X-100, 0.5 Tris 0.06M EDTA pH 8.0. Solution cleared. After lysis, left at RT for 15 to 20 minutes. May heat to 37^o.

4. Spun solution in SW27.1 rotor in Beckman L8-80 Ultracentrafuge for 1 hour at 4^o in large polyallomer tubes at 20,000 rpm.

5. Removed from centrifuge. Poured supernatant into polyallomer tubes and added 10.2 ml 30% PEG 1.5M NaCl. Mixed by inversion. Left on ice for 15 minutes. Spun in SS34 rotor at 4^o for 15 minutes at 3,000 rpm in Sorvall centrifuge.

6. Dissolved pellet gently in 3.0 ml DNA buffer (0.05 Tris, 0.01 EDTA pH 8.0) using blunt ended pipette.

7. Ethanol precipitated by addition of 1/10 volume of 3M Na_2Ac

and 2 1/2 volumes of ice cold Ethanol. Left in $-20^{o}C$ freezer overnight.

8. Thawed. Spun in Beckman L8-80 Ultracentrafuge using SW-40 rotor at $4^{o}C$ at 20,000 rpm for 20 minutes with brake. Washed into 80% EtOH. Spun at 20,000 again. Dried.

9. Dissolved DNA in 400 ul DNA Buffer. Transferred to Eppendorf. Added 400 ul of phenol. Gently agitated for 1 minute. Spun in Eppendorf to clear lid. Added 400 ul ethylalcohol/chloroform. Spun. Removed supernatant and kept. Added 50 ul of DNA buffer to phenol to wash out any remaining DNA. Vortexed. Spun. Removed supernatant and added to other supernatant 1/10 volume 3M NaAc. Added 2 1/2 - 3 volumes of ice cold EtOH and left at $-20^{o}C$ overnight. Put in ice bath. Thawed and spun. Removed supernatant. Added 80% ice cold Ethanol to wash. Spun. Dried in Savant Speedvac.

10. Read concentration of DNA.

Dissolved pellet in DNA buffer (between 50-200 ul depending on size). Remove 1.0 ul and added to 500 ul H_2O. Read on spectrophotometer at 260 nm.

Concentration of DNA = 1 OD^{260} = approx. 50 ug/ml.

$$\text{DNA concentration} = \frac{50 \times \text{dil. OD}^{\text{reading at 260}}}{1000} = x \text{ ug/ul.}$$

DNA Probes

Nick translation - Biotinylated HSP and TNF inserts
(dUTP - deoxyuridine triphosphate)

	Buffer A	DNA	dUTP-Biotin	Enzyme	H_2O

HSP	5 ul	3.7 ul	2.5 ul	5 ul	33.8 ul
TNF	5 ul	3 ul	2.5 ul	5 ul	34.5 ul

Added the above amounts into separate 1.5 ml microcentrifuge tubes (sitting in ice). Incubated both tubes for 1 hour at 15°C. Added 5 ul of stop buffer.

Took a pipette and put siliconized glass wool in the bottom of it. Labeled sixteen 1.5 microcentrifuge tubes with the numbers 5 to 20 and set aside. Rinsed through the pipette with SET (50mM Tris pH 7.5, 1mM EDTA, 100mM NaCl). Added Sephadex G50-150 before the SET ran through. When the beads had almost reached the top of the column equilibrated the column with SET + 0.1% SDS. The nick translation was applied to the column and three 150 ul increments of SET with SDS and let the liquid drip into the first tube. Additional 150 ul of SET with SDS were applied to the column until the fifteen remaining tubes have 150 ul of solution in each of them.

A small piece of nitrocellulose was cut and marked into sixteen squares with the numbers 5 to 20. The strip was spotted with 1 ul of each of the sixteen samples on the corresponding square and baked at 80°C under vacuum for 30 minutes. Strip was wetted in Buffer 1 (100mM Tris-HCl pH 7.5, 150mM NaCl) for 1 minute and transferred to a heat sealable plastic bag. Buffer 2 (3% BSA in Buffer 1) was added and the bag sealed and placed in a 65°C water bath for 1 hour. The filter was removed and placed in a solution of Streptavidin conjugated to alkaline phosphase and agitated gently for 10 minutes. The filter was then washed twice in Buffer 1 for 15 minutes each wash. Washed again for 10 minutes in Buffer 3 (100mM Tris-HCl pH 9.5, 100mM NaCl, 50mM

$MgCl$). Sealed the strip with 7.5 ml of Buffer 3 and the dye in a plastic bag and placed in a dark area.

Observed the location of the DNA (it should show up between tubes 7 through 10) and combined the corresponding tubes.

Hybridization

Wetted the two halves of the Southern blot filter in 2xSSC and sealed in separate plastic bags.

In two different tubes added 10 ml Formamide, 5 ml 20xSSPE, 2 ml Denhardt's (2% BSA, 2% Ficoll, 2% Polyvinylpyrollidone), and 2 ml Dextran Sulfate. Took one of the tubes, added 1 ml of heat denatured Salmon Sperm DNA, and added 10 ml of the solution to each bag and left in a waterbath overnight at 42°C.

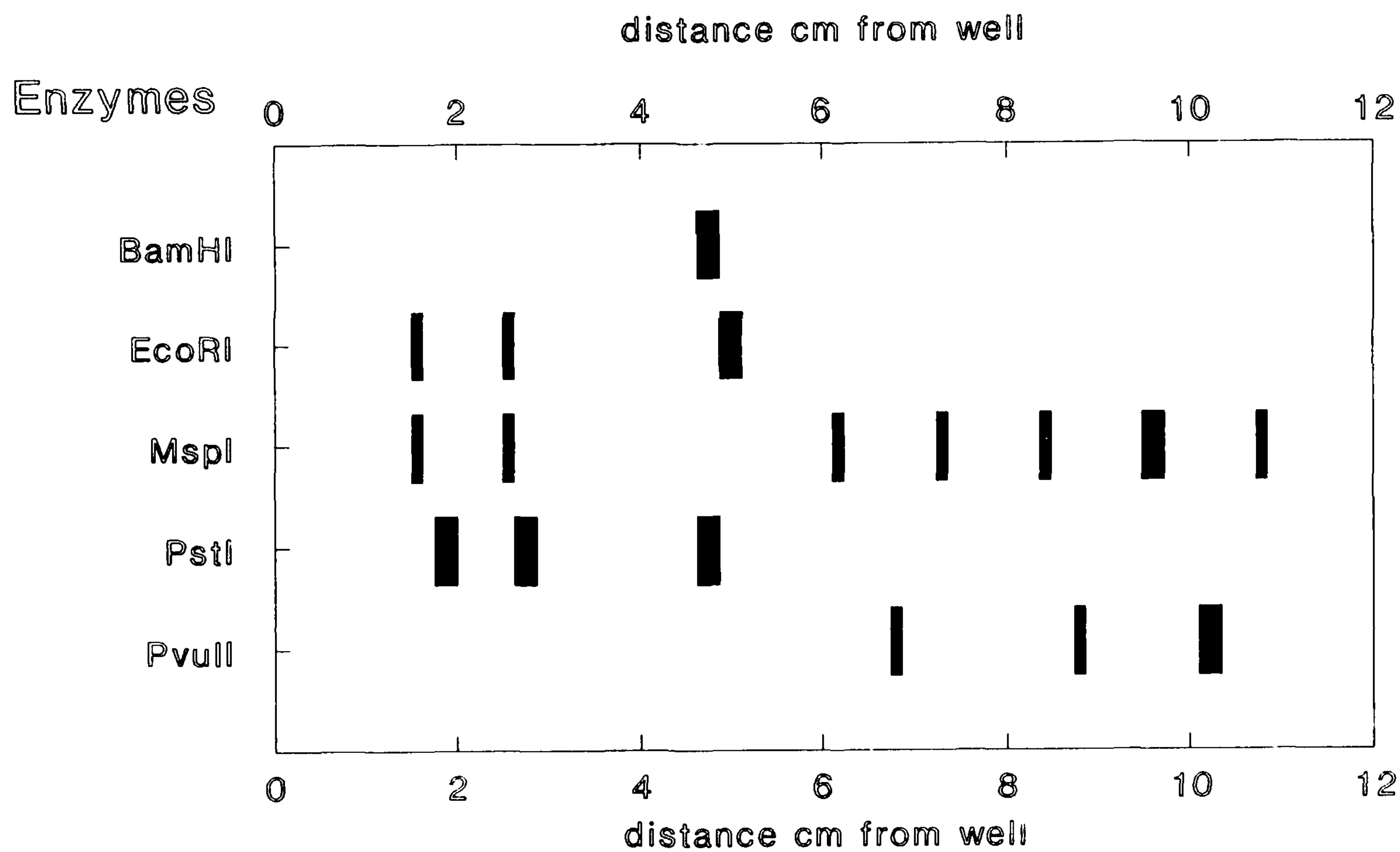
Boiled 1 ml Salmon Sperm DNA for 10 minutes and added it to the unused tube of hybridization solution. Removed the prehybridization solution and added 9 ml of the hybridization to each of the filters. Boiled and rapidly cooled biotinylated TNF DNA and biotinylated HSP DNA and added to the appropriate filter. Sealed the filter and left overnight in a waterbath at 42°C.

Filters were then washed in accordance with the biotin staining procedure as stated in the staining of the test filter.

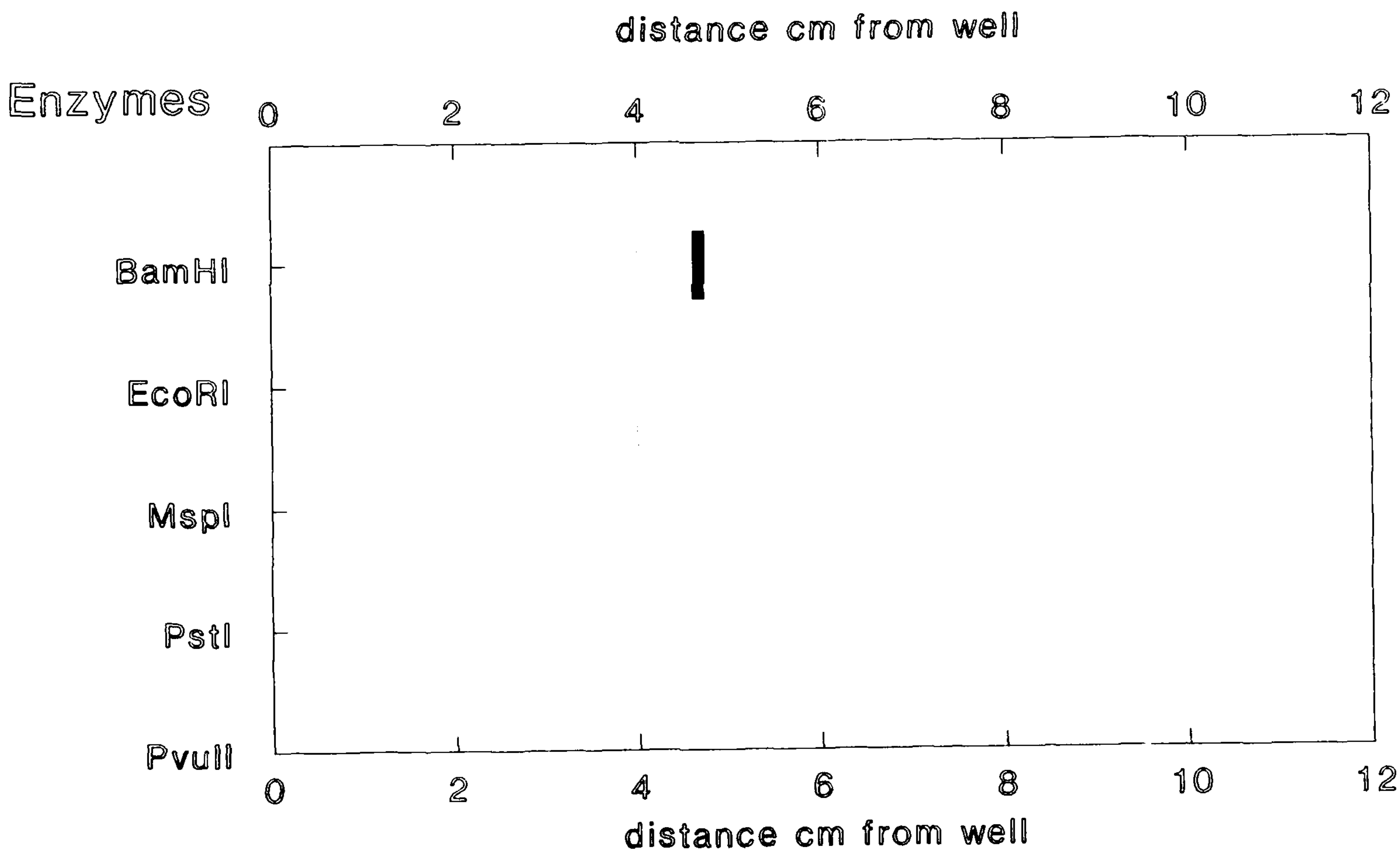
Sealed filter and placed in dark area. Observed color reaction and recorded results.

RESULTS

T.NF PROBE HYBRIDIZATION



HSP PROBE HYBRIDIZATION



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I would like to thank Drs. Russel Burton and Johnathan Kiel for providing an excellent working environment. A special thanks is extended to Dr. Jill Parker for her endless patience and determination in teaching me molecular genetics. Thanks to Dr. Carolyn Alexander-Caudle and the staff at RZP for a rewarding summer.

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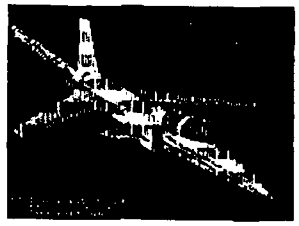
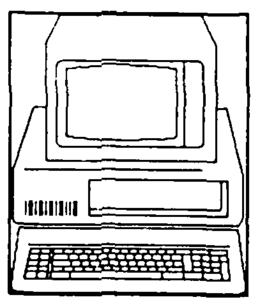


FINAL REPORT: APPRENTICE PROGRAM SUMMER 1989

LORI OLENICK

USAF SAM/VNB
MENTOR: WILLIAM STORM



ACKNOWLEDGEMENTS

Without the help, understanding and patience of the following people, my apprenticeship at Brooks would not have been as enjoyable or educational as it was. My thanks and appreciation goes to each of them whole-heartedly.

Jonathan French, Ph.D
Patrick Hannon, Ed.D
W. Storm, Ph.D
Jeff Whitmore

My Summer as an Apprentice

My summer as an apprentice was spent working with Jonathan French, Ph.D, and Patrick Hannon, Ed.D., on their study entitled "The influence of broad spectrum illumination on circadian neuroendocrine responses and performance." Before I began my apprenticeship here, I knew very little about how research was actually done. (It is nothing like a high school chemistry lab!) However, with their patience and help, I have learned a great deal more this summer than I expected. By helping them with their study, I have observed what research is like at all stages, from the planning steps of getting the study underway, to the display of data in graph form. My stay here has been exciting as well as informative. Because I spent most of my time working on the light study, that is what I chose as the topic of my paper.

Background

Recently, it has been demonstrated that bright, white light may acutely suppress the production of the pineal hormone melatonin. (See figure 1.) Other studies here indicated that melatonin, a naturally occurring sleep compound, has a depressant effect upon performance, attention and motor activity in mammals, including humans. Therefore, the purpose of this study is to determine if wide-spectrum illumination has an effect on plasma melatonin and if "light treatment" can reduce fatigue and enhance performance by suppressing melatonin production. This is important because light treatment has many beneficial uses. For instance, it can be used to "reset" an individual's biological clock, treat seasonal affective disorder (SAD), and even treat jet lag. Another application of light treatment is in lighting offices with special lights, such as Vita-Lites, a broad spectrum bulb made by the Durotest Corp.

Description of Research

Two groups each of five male subjects arrived at the lab at 0700 and were prepared for the measurements that were taken every two hours throughout the study. This preparation included the insertion of intravenous catheters heparinized to prevent the subject's blood from clotting inside the catheter. The subjects were also set up for the electroenophalogram (EEG), electrooculogram (EOG), and electrocardiogram (ECG) measurements that were taken immediately after the blood draws. The subjects were then seated in five separate booths under lights which were adjusted according to the treatment condition. Under the "dim" condition, the subjects sat beneath a light providing approximately 100 lux illuminance, which was measured from the subject's eye level. The bright condition provided the subject with approximately 3200 lux. (See table 1.) The lights used were broad-spectrum Vita-lites that were "burned in" for a minimum of 100 hours before use. The study was a repeated measures design in that each subject received all treatments. In order to prevent the subjects from prejudicing the results, they were told that the dim light was a "focused" condition and the bright light was a "diffuse" condition. They were told that both conditions were important and were encouraged to give their very best performance.

Each subject's performance was measured by using a battery of computer role playing tasks including the Walter Reed Performance Assessment Battery (WPAB), the Complex Cognitive Battery (CCAB), and the Naval Aerospace Medical Research Institute battery (NMRI). These tests measured the subject's reaction time and his reasoning skills. The subjects underwent a training session between 0915 and 1600 to stabilize performance. After this, the actual testing began and lasted until 1115.

A 25cc blood sample was drawn and a 3ml saliva sample was also taken for analysis. This was to determine if correlation could be found between salivary and plasma levels of melatonin and cortisol. Such a finding would enable a non-invasive monitoring of neuroendocrine levels in later studies. In addition to these samples, the subject's EEG, EOG, AND ECG measurements were taken. The performance tests, blood and saliva and electrophysiological measures completed one trial. There were nine experimental trials which occurred every two hours. (See Table 2.) I helped to prepare the subjects for these electrophysiological measurements by (1) carefully selecting the electrode site (2) cleaning the area with omni-prep, and (3) placing the electrodes, embedded in conductive paste, on the subjects. I also helped in preparing for the blood draws. Before the study began, I prepared tubes with 200 units of heparinized saline so that the blood would not clot after it was taken. After the blood was drawn, I took it to the biochemistry lab where it was spun in a centrifuge for five minutes. After this, I pipetted the plasma fraction into the prepared tubes and stored it for later evaluation.

The data from the computer tasks were printed to files and brought into a word processor for analysis. My role in this was to prepare the data for the statistician. To do this, I used a Zenith 248 computer (AT class) networked to an HP Laserjet printer to process the data. The software programs used were Wordperfect version 5.0 and Lotus 1-2-3, version 2.01. These were used to compute averages and generate graphs. Along with sorting the data, I analyzed the subject's body temperature and made a graph of the results. (See figure 2.) As shown in the graph, the diffuse group had a higher temperature during the morning hours. Since body temperature is lowest when melatonin is elevated, these data suggest melatonin was suppressed by the bright light.

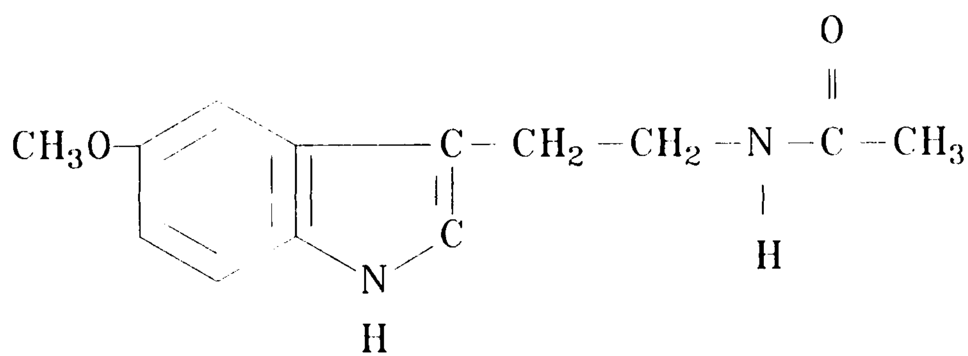
Results

Because the study is not yet completed, the results are only observational. However, by observing the subjects, entering their responses, and reading their responses to fatigue surveys, I believe that the subjects were affected by the light treatment in a positive way. They appeared to be livelier than would be expected in the early morning (0100-0300) when treated with the bright light condition. These subjects were all rather good natured and this made it difficult to determine exactly how tired they were just by looking at them, but I believe that there will be a significant difference between the dim treatment and the bright treatment. However, as a careful scientist, I realize that observation data may be biased and that I must wait for the statistical results to be sure.

Conclusion

The light study was my primary interest this summer, but not my only one. I attended lectures given by individuals that are participating in the UES program for college faculty members. I also attended some lectures given at the Brooks AFB School of Medicine which I found very interesting and understandable. When not working on the light study, I helped Dr. French, and Dr. Hannon prepare lectures that they had to present. I made slides, created graphs in Lotus, and helped to prepare for the study by taking care of minor details, like preparing a data packet of questionnaires for each subject. I also found it very interesting to visit other labs on base to see what they were working on, like high G stress and altitude induced hypoxia. I have found my summer to be very interesting and I have learned a great deal about the behind-the-scenes work of research. In conclusion, it has been a wonderful learning experience and a magnificent summer and I am sorry to see it end.

FIGURE 1



MELATONIN ($C_{13}H_{16}N_2O_2$)

(N-Acetyl-Methoxyserotonin)

FIGURE 2

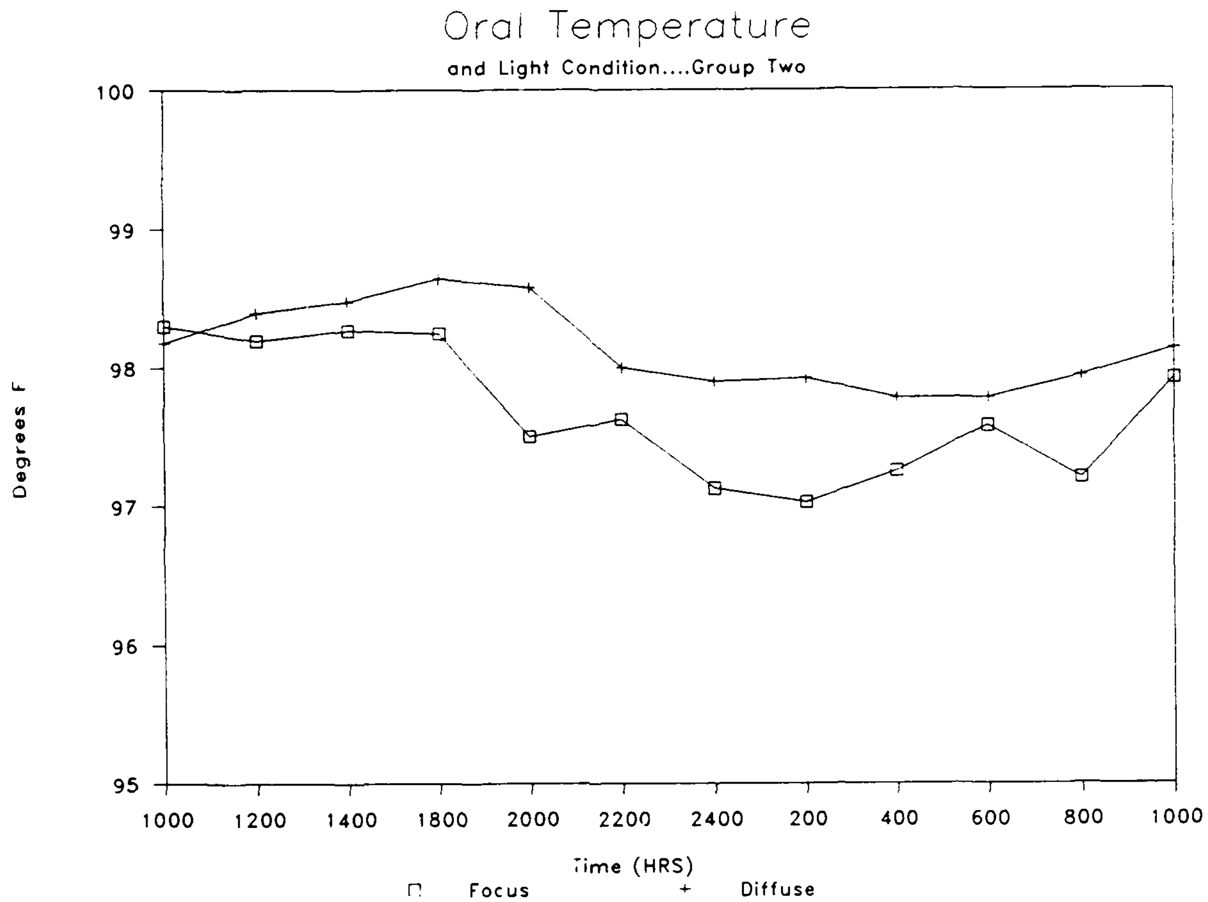

Oral Temperature
and Light Condition....Group Two
100
99
98
97
96
95
Degrees F
1000
1200
1400
1800
2000
2200
2400
200
400
600
800
1000
Time (HRS)
Focus
Diffuse

Table 1

Lighting conditions and schedules for subjects during light induced melatonin suppression and fatigue study.

		Stabilize 0800-1600		Treatment 1600-0800	Duration 0800-1000		Duration 1000-1200
GROUP 1.	WEEK 1:	Dim	-	Dim	Dim	(Dark Adapt)	Dim
	WEEK 2:	Dim	-	Bright	Dim	(Dark Adapt)	Dim
GROUP 2.	WEEK 1:	Dim	-	Bright	Dim	(Dark Adapt)	Dim
	WEEK 2:	Dim	-	Dim	Dim	(Dark Adapt)	Dim

Dim = 100 lux measured from subject eye level
Bright = 3200 lux measured from subject eye level
Dark Adaptation will be performed individually in a separate room illuminated by at most 5 lux and will require only about 5 minutes per subject.

Table 2
SCHEDULE OF EVENTS

0700	Arrive in Lab 24x
0800	Preparation for measurements
1000	Trial 1 Performance and mood tests
1045	Electrophysiological tests/ Blood saliva/temperature
1115	MEAL
1200	Computer role playing tasks-Practice
1400	Trial 2 Performance and mood tests
1445	Electrophysiological tests/ Blood saliva/temperature
1515	Computer role playing tasks SNACK
1600	Trial 3 Performance and mood tests
1645	Electrophysiological tests/ Blood saliva/temperature
1715	MEAL
1745	LIGHT TREATMENT BEGINS
1800	Trial 4 Performance and mood tests
1845	Electrophysiological tests/ Blood saliva/temperature
1915	Computer role playing tasks
1945	MEAL
2000	Trial 5 Performance and mood tests
2045	Electrophysiological tests/ Blood saliva/temperature
2115	Computer role playing tasks
2200	Trial 6 Performance and mood tests
2245	Electrophysiological tests/ Blood saliva/temperature
2315	SNACK
2400	Trial 7 Performance and mood tests
0045	Electrophysiological tests/ Blood saliva/temperature
0115	Computer role playing tasks
0200	Trial 8 Performance and mood tests
0245	Electrophysiological tests/ Blood saliva/temperature
0315	Computer role playing tasks SNACK
0400	Trial 9 Performance and mood tests
0445	Electrophysiological tests/ Blood saliva/temperature
0515	MEAL
0600	Trial 10 Performance and mood tests
0645	Electrophysiological tests/ Blood saliva/temperature
0715	Computer role playing tasks
0745	LIGHT TREATMENT ENDS
0800	Trial 11 Performance tests and mood tests.
0845	Electrophysiological tests/ Blood saliva/temperature
0915	Computer role playing tasks SNACK
1000	Trial 12 Performance and mood tests
1045	Electrophysiological tests/ Blood saliva/temperature
1115	Computer role playing tasks.
1115	Dark Adaptation Test

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1989 USAF-UES HIGH SCHOOL APPRENTICESHIP PROGRAM

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FINAL REPORT

NEUROCHEMISTRY OF PHOTIC ENTRAINMENT OF THE CIRCADIAN ACTIVITY RHYTHM IN THE SYRIAN HAMSTER

PREPARED BY:	JOANNA C. SAUCEDO
ACADEMIC RANK:	HIGH SCHOOL JUNIOR
SCHOOL:	EAST CENTRAL HIGH SCHOOL
RESEARCH LOCATION:	BROOKS AFB
	SAM/NGNS
	SAN ANTONIO, TEXAS 78235
USAF RESEARCHER:	MICHAEL A. REA, PH.D.
DATE:	AUGUST 24, 1989

ACKNOWLEDGEMENTS

I've enjoyed my stay at Brooks AFB and would very much like to thank the faculty and graduate workers for the time, friendship and support they've offered me during my eight week apprenticeship. It was not only a great educational experience, but also a way to become better acquainted socially with persons who pursue careers in a field that I most assuredly am inclined to follow in the future. I thank Dr. Rea for giving me opportunities I would have never had (maybe somewhere a lot longer down the line) and would lastly like to express my deepest gratitude to him for trusting and allowing me to do the many tasks he assigned me to undertake.

INTRODUCTION

Life-forms on earth have had to adapt their behavior to the rising and setting of the sun. We wake up in the morning and fall asleep when night falls upon our region of the world. Daily rhythms in our behavior (e.g. activity, sleep) and physiology (e.g. body temperature) are referred to as circadian rhythms. These rhythms are part of a system in which a biological clock controls the behavior and physiology of a person or animal such that it becomes entrained to the daily light-dark cycle. This fascinating mechanism is thought to be located in the suprachiasmatic nuclei (SCN), which lie at the base of the brain in the hypothalamus and are situated just above the optic chiasm on either side of the third ventrical. This location enables the SCN to receive information directly from the optic nerves and explains how the SCN can be entrained by light stimuli.

Finding more information about this biological clock is the goal of the Circadian Neurobiology Research Program. This program aims to find out exactly how light entrains the SCN and to understand the neurobiological basis of circadian rhythmicity. Better knowledge of the neurochemical processes of this mechanism could make possible the development of drugs that prevent the effects of jet-lag in humans. This research will provide information leading to the identification and localization of other neurotransmitters that are responsible for circadian rhythmicity in mammals.

When an animal is maintained under a light-dark (LD) cycle, its circadian rhythms become entrained to the LD cycle. This means that daily behavioral and physiological events occur at about the same time of day relative to the onset of light or darkness. Since hamsters are nocturnal rodents, they tend to become active shortly after lights out (Fig. 1 A). When conditions of constant darkness are imposed upon these rodents, the activity rhythm persists. However, the period of this so-called "free-running" rhythm is usually slightly different than 24 hours (Fig. 1 B). Under the condition of constant darkness, light can be used as a test stimulus and the effect of short light pulses on the circadian clock can be observed. When hamsters are exposed to a 15 minute pulse of light given late in the active phase, the clock is set forward (phase advanced), and activity begins earlier than predicted from behavior prior to stimulation (Fig. 1 C). Using this experimental model, we would like to determine the biochemical process by which the light pulse resets the clock.

We conducted two experiments. The first experiment was designed to determine the amount of light needed to cause a submaximal phase advance. The goal of the next phase in this experiment is to block light-induced phase shifts by injecting a neurotransmitter antagonist directly into the SCN before giving the light pulse. Glutamate is the most likely candidate neurotransmitter to be involved in this process. The glutamate antagonist that we plan to use is kynurenic acid.

EXPERIMENT 1

The first experiment was designed to determine the light stimulation conditions which cause a submaximal phase shift of the activity rhythm. Free-running hamsters were exposed to 15 minute pulses of light at intensities between 33 and 22000 lux and the resulting phase shifts of the activity rhythm were measured.

METHODS

Eighteen activity cages equipped with 14 inch running wheels were prepared by assembling the electrical mechanisms that enabled a Zenith 248 microcomputer to count wheel turns. This was achieved using magnetically controlled reed switches which were activated by a magnet attached to the running wheel. The reed switches were connected to the computer using flat computer cable. The computer could monitor up to 20 cages simultaneously. After assembly, each cage was tested with a multimeter to insure they were in good working condition.

Adult, male, Syrian hamsters were used in this study. Hamsters were then placed into the cages after the electrical attachments had been checked a second time. This was done by turning the wheels, counting the revolutions, and comparing this number to the one displayed on the computer screen.

During the first six days of the experiment, the hamsters were maintained under a light-dark cycle of 14 hours of light and 10 hours of darkness (LD 14:10). Under LD 14:10, every animal displayed a stable, entrained activity rhythm. The animals were then kept under constant dim red light (intensity determined to be less than 1 lux) for an additional 10 to 12 days. Activity data collected during this period was used to calculate the time of activity onset, defined as circadian time 1200 (CT12), on the day of planned light stimulation. This was achieved using a computer program which fits the times of activity onset over the 6 days prior to stimulation to a regression line and extrapolates this line to the projected day of stimulation. Each of the hamsters was stimulated with a fifteen minute pulse of light at an intensity of either 22000, 2850, 250, or 33 lux. The pulses were given at CT18, the time denoted as six circadian hours after activity onset. Decoursey (1964) and others have reported that light stimulation at this time causes phase advances of the activity rhythm in hamsters. CT18 was calculated for each animal using the period of the free-running rhythm (tau) and the predicted time of activity onset (CT12) as shown in equation 1.

$$\text{(1)} \qquad CT18 = CT12 + \frac{tau}{4}$$

The instrument used for the light stimulation process was devised by Dr. Rea and Brian Davis. This device consisted of a Tungstsen-Halogen lamp which allowed light to pass through a pair of collimating lenses, a glass infrared filter and, finally, through a series of neutral density filters that enabled light intensity to be adjusted. Each animal was placed in a white cylindrical chamber (to make sure the light would be distributed evenly) and covered with optical diffusion glass while light stimulation was being administered. After stimulation, the hamsters were returned to DD for a period of thirteen days.

RESULTS

The results obtained from this study show that as the intensity of the light stimulus increases, so does the magnitude of the phase shift of the activity rhythm (Fig 2). However, the hamsters showed considerable variability in their response to stimulation. Although a light intensity of 250 lux appeared to cause the most consistent phase advances, we were unable to determine the optimal, submaximal stimulation condition (Fig 3). This study is currently being repeated.

EXPERIMENT 2

The purpose of this experiment was to attempt to block light-induced phase advances by microinjecting kynurenic acid directly into the SCN prior to light exposure. However, it was first necessary to (1) develop the stereotaxic surgical technique, (2) determine the stereotaxic coordinates for the SCN, and (3) determine the effect of microinjection of the antagonist alone on the activity rhythm.

METHODS

During the last few weeks of the first experiment, preparations for the second study had already begun. Stereotaxic microinjections of 300 nL of a solution of methylene blue dye into the hypothalamus of anesthetized hamsters were performed. Initial coordinates were obtained from the literature (Meijer et al., 1988) and from the Paxinos stereotaxic atlas of the rat brain (Paxinos, 1986). The hamsters were sacrificed and processed for histological examination of the brain tissue which included the SCN so that information about the position and spread of the dye could be obtained. In this way, stereotaxic coordinates for the SCN were determined to be, from Bregma, 1.5 mm anterior, 1.5 mm lateral, and 7.7 mm below the dura with the cannula oriented at 10° from vertical. After coordinates were established, 26g guide cannulae were surgically implanted in the skulls of several hamsters according to these coordinates (2.5 mm below the dura), and fixed in place with aneuroplastic cement. Dye was then injected via a 33g infusion cannula through the implanted guide cannula and the animals were again sacrificed to confirm that the cannulae were positioned correctly and that the dye spread was moving to the SCN as desired.

Eighteen hamsters were fitted with 26g guide cannula and allowed about two days to recuperate, although several hours was sufficient in many cases. After this post-operative time, the animals were checked to make sure that their cannulae were stable and patent, and that the sutures and aneuroplastic cement were still in place. Some animals were removed from the study at this point. Hamsters with stable cannulae were introduced to wheel cages under LD 14:10. Twelve cannulated animals displayed robust, entrainable activity rhythms within 5 days after surgery (Fig 4). These animals were divided into 2 groups. After 8 days under DD, one group received microinjections of 300 nL of 10 mM kynurenic acid in artificial cerebrospinal fluid (aCSF) at CT18. The remaining hamsters served as a control group and received aCSF injections without kynurenic acid.

RESULTS

No phase shifts were observed in animals that received microinjections kynurenic acid (Fig 4). Therefore, the effects of kynurenic acid on light-induced phase shifts can now be investigated. However, since we failed to establish optimal light stimulation conditions in experiment 1, the final phase of the experiment must be delayed until more data is obtained. Dr. Rea will microinject dye into the cannulated hamsters used in experiment 2 to insure that the drug injections occured in the SCN.

FURTHER OBSERVATIONS

Not only have I had the chance to absorb information on the various areas of science that we have been researching, but I have also had the chance to look in on experiments being perfomed by other scientists and technicians in the School of Aerospace Medicine. I was invited to attend lectures every Thursday on many different areas of science, mathematics and medicine that have broadened my level of understanding to include aspects of life science that are only now being investigated. Even my knowledge of the anatomy of animals and the physiology of neurons has been enhanced by my apprenticeship.

Working with older, more experienced people has taught me a lot about the "real world" and has given me insight on people in general. Many graduate students and college-bound high school students who were participating in UES programs were available and provided me with very useful information on college scholarships, preparations, life in college, the studies, the people, and the major necessities of college. I even had the chance to learn about colleges that I am considering attending and find out which would best suit my interests and needs. I have observed intelligent people reason out their problems and tackle technical difficulties head on. It has been an experience with benefits I could have never imagined. This is a summer I truly would not trade for anything else I could have done during these past eight weeks. It has been a tremendous experience.

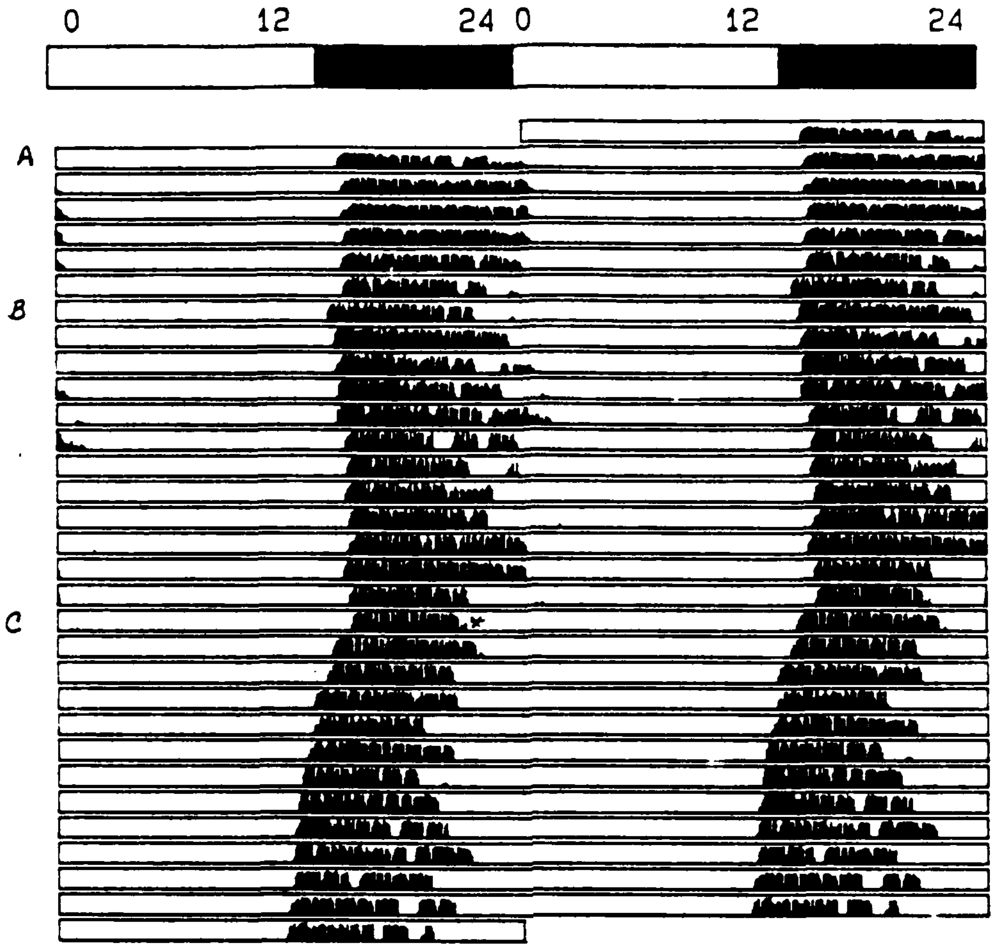

Figure 1. Activity record for a male Syrian hamster. The black vertical bars represent 6 minute bins of activity and the height of the bars is proportionate to the number of wheel turns occurring during that period. This record is "double plotted".

A. Entrainment of the rhythm to the light-dark (LD) cycle. This animal was initially maintained under LD 14:10, as indicated by the white (light) and black (darkness) bar at the top of the figure. Activity began approximately 1 hour after lights-out.

B. Free-running activity rhythm. On the morning of day 7, the lights remained off, resulting in a small phase advance of the activity rhythm. The animal began to free-run, revealing an endogenous period of 24.13 hours.

C. Light-induced phase shift. On day 19, the hamster was stimulated with a 15 minute pulse of 250 lux of white light at CT18 (*) resulting in a 137 minute phase advance of the activity rhythm.

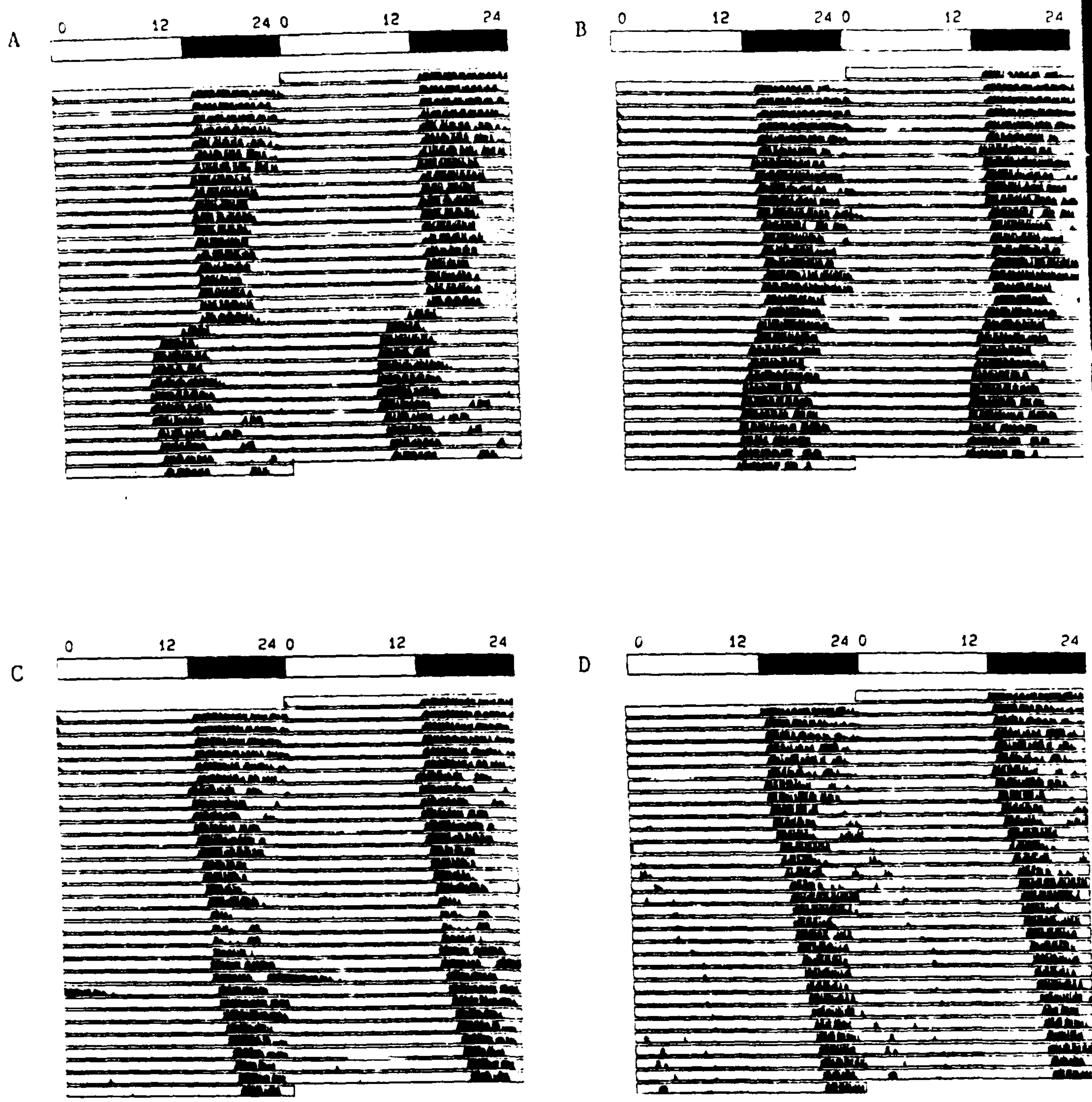

Figure 2. Light-induced phase advances of the circadian activity rhythm Shown are selected records obtained from hamsters that received 15 minute light pulses at CT18 (*) of white light at intensities of either (A) 22000 lux, (B) 2850 lux, (C) 250 lux, or (D) 33 lux. Details of the activity records are described under Figure 1.

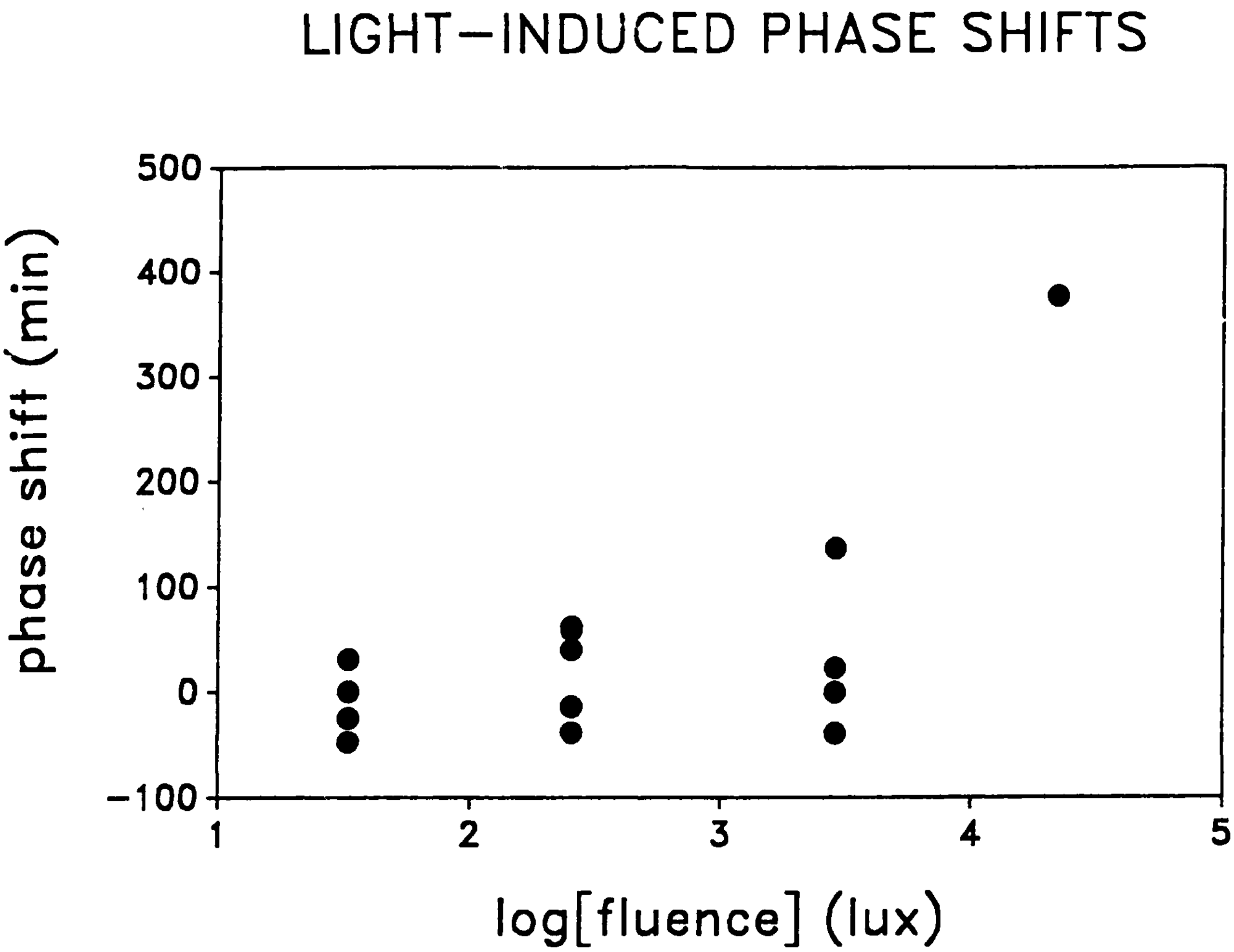

Figure 3. Fluence-response data for light pulse-induced phase shifts of the circadian activity rhythm in hamsters. Each dot represents the magnitude of the phase shift observed in response to a 15 minute pulse of white light at an intensity of 33 (n=4), 250 (n=5), 2850 (n=4) or 22000 (n=1) lux.

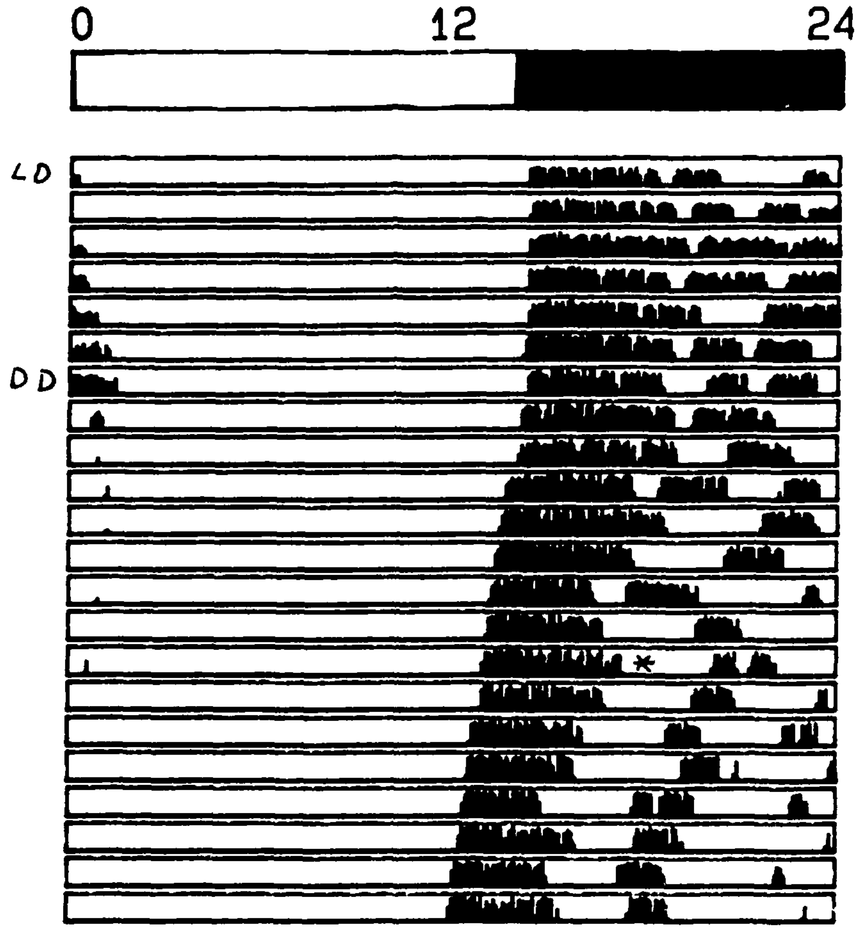

Figure 4. Representative activity record from a hamster that received a 300 nL injection of 10 mM kynurenic acid in aCSF. A 26g stainless steel guide cannula was stereotaxically implanted 3 days prior to the beginning of this record. The hamster was initially housed under LD14:10 (time bar) and showed entrainment of the activity rhythm indicating an intact retinohypothalamic tract and functioning pacemaker. On day 6 the animal was transferred to DD. After 8 days under DD, the animal received an injection of kynurenic acid at CT18 (*). No effect of the drug on the free-running activity rhythm was observed.

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UES REPORT -- Summer 1989

John M. Taboada

This summer proved to be exceptionally interesting for me with my participation in the Air Force Apprenticeship Program. The program allowed me to observe an active research and development organization, participate in technhcal meetings, attend lectures and work on my own research project.

The organization I worked in this summer is the Vision Biophysics Laboratory in the Clinical Sciences Division of the School of Aerospace Medicine led by Dr. John Taboada, an Air Force research physicist who coincidently is my dad; but this relation neither helped nor hindered me. My assignments were intensely technical. I have basically finished the development of a new computer controlled electronic analyzer for spectroscopy with a video camera; something I have been persuing for three years. Other members of the organization included Dr. Rex Moyer, a biology professor from Trinity University, and two of his graduate students, Dagmar Futl and George Kim. In addition, I worked very closely with Will Robinson, an electrical engineering UTSA graduate co-op student, and Air Force Captain John Barber who also is an electrical engineer. I also met and interacted with university students Tito Aldape, Karl Rodriguez, David Gaines, and Theresa Phillips who were working on photoisomerization of retinal substance in the eye that initiates the visual sense of a photon.

Regarding meetings, on the 29 June 1989, I joined a meeting of Dr. Taboada, David Gaines, and Will Robinson with research scientists at Southwest Research Institute-Drs. Ralph Hill, David Naegeli, and Steve Willinghoff. This discussion dealt with the new technology of synthetic micro-tubules loaded with non-linear optical materials. This exciting development initiated at the Naval Research Laboratory is the subject of potential mutual research projects between Southwest Research Institute and the Vision Biophysics Laboratory under a "Technical Transfer" agreement. On the 10 August 1989, Dr. John Phillips of Indiana University, department of biology, visited the laboratory and presented a lecture on magnetic field sensing by insects' visual system. This research topic is very interesting becuase it seems that there is a natural detector for magnetic fields in the vision transduction process. That is, photons and magnetic fields are connected.

My own work centered on developing a fast circuit that would integrate the signal in a video frame pertaining to specific regions of a spectrum. Basically, this system would work as follows: The system would take an incoming vido signal and separate it into its vertical and horizontal sync signals. The sync signals were used as timing devices f... the rest of the circuit. The voltage going to a single colum of a television screen was accumulated using a stair-case storage system. Next, the voltage from the capacitor was converted to a digital signal using an 8-bit A/D converter. Using this technique, 500 columns of 100 rows were digitized in about ten seconds.

This relatively low-cost spectrum analyzer could have broad Air Force application in the analysis of spectra. For example, it could be used in the rapid determination of the transmission spectra of aircraft canopies and windscreens. I am very pleased to have had the opportunity to contribute to the Air Force mission by working intensely on this design and system.

The research program of the Vision Biophysics Laboratory is extremely varied dealing with basic questions of how the eye detects light to concerns about laser radars and robotic vision. The impressive thing is that all this relates directly to problems of Air Force concerns.